An Investigation into the Injury Incidence and Training Habits of Group Fitness Instructors via a Retrospective Database Analysis

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Abstract

Introduction. Les Mills International distributes group fitness classes to over 18,000 fitness facilities worldwide. These classes are taught by over 130,000 group fitness instructors. These instructors are required to simultaneously coach and demonstrate each class physically at a high level. Previous studies have demonstrated significant injury risk for instructors and participants when undertaking group fitness programs. As yet the specific injury risks and factors contributing to these injuries for Les Mills instructors is unknown.

Purpose. To investigate the relationship between age, training history and incidence and intensity of pain and injury in the spine and lower limb in Les Mills group fitness instructors via retrospective data analysis.

Method. Three thousand two hundred and eight Les Mills instructors completed a retrospective online survey, providing details on regional pain, training history and intensity of injury over a six month period. The sample was made up of 2614 females and 594 males.

Results. Training volume was associated with the reporting of any pain in female participants with those in moderate training volume categories being at most risk. The age of instructors had a significant relationship with the recording of any pain and specifically lower limb pain in females with older groups recording less pain. Older participants also had a lower intensity of injury in the male group. Regular core training resulted in reduced odds of reporting spinal and lumbar pain in females while increasing the likelihood of reporting knee pain in males. Undertaking regular flexibility training increased the odds of reporting spinal, lumbar, hip and lower limb pain in females and males. Strength training increased the odds of reporting lumbar and spinal pain in males. Undertaking high impact programs on a regular basis increased the likelihood of reporting knee and lower leg pain in females and males. The frequency of participating in regular bodybalance classes was associated with the intensity of injuries in females while age, frequency of bodypump classes and regular strength training effected the intensity of injuries in males.

Conclusions. These findings highlight risks and benefits of teaching and participating in various types of group fitness classes and adopting various training practises outside of group fitness in Les Mills instructors. These factors should be taken into consideration when instructors organise their weekly teaching and training schedules.

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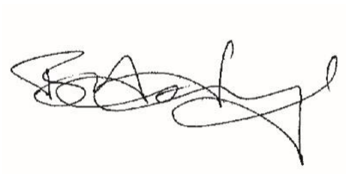

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Chapter 1 Introduction

1.1 Statement of the problem

Les Mills International is a New Zealand based fitness company that has a simple mission, to create a fitter planet. To achieve this, they create and distribute group fitness classes to over 18,000 gyms worldwide. These classes are delivered by over 130,000 instructors who lead participants through 13 different formats ranging from weight training classes to yoga and dance workouts. These instructors are a highly passionate, athletic group of individuals who have been instrumental in the success of the business, not to mention, changing the lives of millions of participants on a weekly basis.

As with any pursuit of a highly physical nature, injury is of concern to these instructors, a significant number of whom teach as a full-time occupation. To address this, Les Mills International creates regular educational videos covering areas such as exercise technique, fitness research and sports conditioning to help instructors stay injury free. They also have a rigorous sign off process during the creative phase of each workout so that instructors and participants alike can be confident that the classes are safe and effective.

In 2016, Les Mills International enlisted the services of Dr Jinger Gottschall, an associate professor of Kinesiology at Penn State University USA, to design an online injury survey which was distributed to the instructors of English speaking countries via the offices in each region. The primary aim of this survey was to investigate common injuries related to each format so that injury prevention videos could be created and the information could be used to assist in the design of the workouts. Dr Gottschall received over three thousand responses to this survey, the findings of the data have resulted in the production of a number of videos, conference presentations and seminars focusing on injury prevention.

While processing the data, it became apparent that the information gained from the instructors opened the door for further analysis. The instructors had provided a 6 month history of the volume and nature of their training (including workouts outside of group fitness classes), along with their age, location of painful areas and the intensity of any injuries they had encountered. Therefore, there was an opportunity to explore relationships between factors, other than specific Les Mills programs, and the reporting of injury.

1.2 The purpose of the study

The purpose of this study is to investigate the relationship between age, training history and incidence and intensity of pain and injury in the spine and lower limb in Les Mills group fitness instructors via retrospective data analysis.

1.3 The significance of the problem

Group fitness is becoming an increasingly popular means of achieving recommended physical activity levels for healthy adults (Middelkamp, Van Rooijen, Wolfhagen & Steenbergen, 2016). As a result, there is an increasing demand for group fitness instructors who are instrumental in delivering the benefits of this type of programming. The need to role model the often high levels of physicality in these classes, in many cases multiple times daily, places these instructors at high risk of injury. No previous study has been conducted on the specific factors that influence the onset of injury in group fitness instructors who teach a variety of formats.

Chapter 2 Literature Review

2.1 Introduction

This study investigates the relationship between age, training history and incidence and intensity of pain and injury in the spine and lower limb in Les Mills group fitness instructors via retrospective data analysis. Les Mills International is a New Zealand based company and is one of the largest producers of group fitness programs in the world. They create a suite of classes ranging from the more traditional high impact aerobics to strength, mixed martial arts based, indoor cycling, flexibility and core training programs which they distribute to over 18,000 health clubs in more than 100 countries around the world (Les Mills International). These programs are delivered by approximately 130,000 instructors who simultaneously coach and participate in the sessions. The physical nature of these sessions exposes these instructors to a degree of risk of musculoskeletal injury. The aim of this review is to summarise the findings of previous studies on injury prevention, the incidence of injury related to group fitness classes and to explore how factors such as age, gender and training load affect the frequency of pain and injury.

2.2 Musculoskeletal Injury Prevention

Group fitness instructors encounter significant physical demands when teaching classes. There is also often a degree of competition when trying to secure regular teaching slots. As a result, time off or impaired teaching performance through injury can be disruptive. Gabbe, Bennell, Finch, Wajswelner, and Orchard (2006) have noted that previous injury has been found to be a high predictor of future injury. The combination of these factors suggest that a comprehensive injury prevention strategy would assist instructors in performing at a consistently high level while allowing them to secure optimal classes on a weekly basis. This is of particular importance when many instructors rely on regular income from these classes.

Van Mechelen, Hlobil and Kemper (1992) describes a “sequence of prevention” comprising of four stages.

Step 1. Establishing the extent of the sports injury problem

Step 2. Establishing aetiology and mechanism of injuries

Step 3. Introducing preventative measures

Step 4. Assessing their effectiveness by repeating step 1

The authors stressed the importance of defining injury and focusing on the incidence rather than frequency of injuries, often expressed as the number of injuries per thousand hours of athletic exposure. Initial data can be explored to assess the scope and nature of the issues related to musculoskeletal injury. Once these parameters have been established, they act as a baseline to allow assessment of the effectiveness of preventative measures (step four is a repeat of step 1).

Van Mechelen et al. (1992) described internal and external risk factors which contribute to injuries. Internal factors such as age, gender, fitness levels and previous injury in addition to external factors such as equipment, playing surface and weather conditions combine to produce an overall level of injury risk. This interaction of factors was elaborated on by Meeuwise, Tyrema, Hagel and Emery (2007) who described a multifactorial model of causation which stressed the importance of assessing the multiple extrinsic and intrinsic predisposing factors. Bahr and Krosshaug (2005) added the inclusion of the inciting event to this model. The recording of details such as playing situation, opponent behaviour and biomechanics can assist in gaining further understanding of the combination of factors leading to injury and therefore enhance the injury prevention model.

The linear paradigm of these models was questioned by Meeuwise et al. (2007). These authors pointed out that in many cases injury does not remove the athlete from participation and therefore there may be no final end point. This observation was supported by Gissane, White, Kerr and Jennings (2001) who viewed risk factors in a more fluid way as they varied according to level of athletic exposure and injury state. They proposed a cyclical injury prevention model highlighting that an injury is not the end point as proposed in the linear models. Alternatively, rehabilitation and return to sport create a continuation of the model. When the athlete returns to competition and therefore re-enters the model, they will be further exposed to risk factors which have now changed due to the previous injury.

Meeuwise et al. (2007) built on this approach with the dynamic recursive model. This model takes into account the fact that adaptations, both positive and negative, occur through athletic exposure both with and without injury that affect injury risk and aetiology in a dynamic, recursive way. They propose a multivariate analysis technique that captures the changing exposure and adaptations prior to injury. The key to this model is that the influence of a risk factor is not static as the exposure to the risk is repeated under variable conditions. Therefore, for injury prevention models to be effective, they need to be adaptable to these variations.

Finch (2006) proposed a sports injury research framework or TRIPP (Translating Research into Injury Prevention Practice) model. This model, built on the previous approaches (Gissane et al., 2001; Meeuwise et al., 2007; Van Mechelen et al., 1992) in the first four stages and added two extra steps to test the implementation of the injury prevention strategies. The author notes that only injury prevention research that is adopted by the various sporting bodies will assist in injury prevention. The stages are outlined below.

Stage 1. Injury surveillance

Stage 2. Establish aetiology and mechanisms of injury

Stage 3. Develop preventive measures

Stage 4. Ideal conditions / scientific evaluation

Stage 5. Describe intervention context to inform implementation strategies

Stage 6. Evaluate effectiveness of preventive measures in implementation context

The aim of this study is to undertake a retrospective database analysis that will attempt to provide information pertaining to the first three factors in the models described in this section. Injury sites of group fitness instructors will be determined, along with potential internal factors, such as age, training volume and training methods that contributed to these injuries. This information will create a platform to move into stage three.

2.3 Musculoskeletal Injury Incidence

The instruction of group fitness classes often requires a high degree of physicality on the part of the instructor. Although recent trends have seen the introduction of more variety in these classes, many have high impact movement patterns and spinal forces that require close consideration with regards to injury prevention.

It has been well documented that sport related activities are correlated to the risk of musculoskeletal injury (Conn, Annest & Gilchrist, 2003). Carlson et al (2006) compared the incidence of non-activity related and activity-specific injuries in US adults with differing leisure-time physical activity levels. The authors found that those who were active had 1.53 greater odds of reporting a sport or leisure time activity injury than an inactive person. Hootman et al. (2002) reviewed data from 1,283 female and 5,028 male 20 – 85 year olds attending the Cooper Clinic, a preventive medicine clinic in Dallas, Texas, and found that men and women who were younger, more physically active and had previous injuries were significantly more likely to suffer an all-cause or activity related injury.

The addition of a period of intense training has been observed to increase the prevalence of injury. Almeida, Williams, Shaffer and Brodine (1999) followed 1,296 randomly selected male Marine recruits who attended 12 weeks of boot camp training. These recruits had an overall injury prevalence of 39.6% within the training period of which 78% were deemed to be non-traumatic overuse injuries. Buist et al (2010) monitored participants undertaking an eight week training regime for a four mile running event. At least one running related injury was reported by 25.9% of those monitored.

The athletic community have also been observed to have high injury rates. Monitoring the injury incidence of athletes belonging to the National Collegiate Athletic Association reveals that these competitors reported an average of 4.0 injuries (requiring at least one days rest) per 1000 athletic exposures in practices and 13.8 injuries per 1000 athletic exposures in competition events. These results varied between sports with football having the highest rates (9.9 injuries per 1000 athletic exposures for practices and 35.9 injuries per 1000 athletic exposures for games) whereas baseball injuries were observed to be 1.9 injuries per 1000 athletic exposures in practice and women's softball recorded 4.3 injuries per 1000 athletic exposures in games (Hootman, Dick & Agel, 2007).

In summary it appears that the benefits of being physically active comes with the risk of musculoskeletal injury. Information gained via Les Mills International state that the global average for instructors teaching classes on a weekly basis is four times per week. This is in addition to other types of training. As stated in the previous studies, this degree of activity in itself creates a degree of injury risk. The next section will focus on studies that have investigated risk associated with various group fitness formats

2.4 Group Fitness Injury Incidence

The following sections are a narrative review following a search of the literature conducted for injuries in dance aerobics, step aerobics cardio kick boxing, yoga, indoor cycling and group fitness instructors. The Scopus, Medline, CINAHL and SPORTDiscus databases, to 1st July 2017 were searched for terms linked with the Boolean operators: Injur* AND aerobic dance, cardio kick boxing etc. Papers were selected based on title, then abstract and finally text. Manual searching of reference lists was used to identify additional articles. Papers were excluded if their content: (i) was unavailable in English; (ii) was unavailable in full text format; (iii) did not provide additional information for any of the identified sections and subsections of this review. Inclusion criteria for all articles were: (i) cross sectional studies or surveys (ii) reported data for injury incidence per 1000 / 100 hours and injury rate ratios.

2.4.1 Aerobic Dance

The papers reviewed in this chapter were selected from a comprehensive Scopus, Medline, CINAHL and Sport Discus data base search from 1985 onwards. Papers were selected if they investigated injuries sustained by participants or instructors as a result of attending aerobic dance classes. These papers are summarised in Table 1.

Table 1. Injury studies on aerobic dance

Study	Study Design	Participants	Injury Prevalence / Rate	Most Common Site of Injury	Frequency of Classes
Francis et al 1985	Retrospective survey	135 instructors 96% female	76.3%	Shin	Average 7.1 classes per week
Richie et al 1985	Retrospective survey	1233 participants 58 instructors Average age 29.9 87% female	Instructors 75.9% Participants 43.3%	Shin	Participants Average of 3.3 classes per week Instructors Average of 4.7 classes per week
Vetter et al 1985	Clinic attendance records	61 female 24 instructors 37 participants Average age instructors 32.8 Average age participants 36.6	Not stated	Foot	Instructors Average of 7.2 hours per week Participants Average of 2.8 hours per week
Garrick et al 1986	Prospective survey	60 instructors 80% female 351 participants 86% female	Instructors 75% 0.93 injuries per 100 hours Participants 44.1% 1.16 injuries per 100 hours	Shin	Not stated
Mutoh et al 1988	Retrospective survey	161 instructors 800 students 82% female Average age instructors 24.7 Average age participants 29.6	Instructors 72.4% 0.17 injuries per 100 hours Participants 22.8% 0.15 injuries per 100 hours	Instructors Lower leg Participants Foot	Instructors 4-5 classes per week Participants 1-2 classes per week
Rothenberger 1988	Retrospective survey	726 participants 84% female Average age 31.5	49%	Shin	Average 195 minutes per week
Requa et al 1993	Prospective survey	986 fitness club members 83% female Average age 32	Participants 19.47 injuries per 1000 hours	Ankle	Not stated

Study	Study Design	Participants	Injury Prevalence / Rate	Most Common Site of Injury	Frequency of Classes
			(jazz funk) 12.03 per 1000 hours (other forms)		
Potter 1996	Retrospective survey	40 participants and instructors Average age 29.4 years	0.23 injuries per 100 hours	Knee	Average of 3.6 classes per week
Du Toit et al 2001	Retrospective Survey	70 participants 80% female Average age 29	77%	Leg	70% taught 7.8 classes per week. 30% taught more than 10 classes per week
Malliou et al 2007	Prospective survey	404 instructors 70% female Average age 27.5 years	58.7% 0.93 injuries per 100 hours		Average of 8.6 classes per week

With the growing popularity of aerobic dance classes in the 1980's a number of studies have been published investigating the prevalence of injuries sustained by both instructors and participants. Five studies conducted retrospective injury surveys (Francis, Francis & Welshons-Smith, 1985; Richie, Kelso & Bellucci, 1985; Vetter, Helfet, Spear & Matthews, 1985; Mutoh, Sawai, Takanashi & Skurko, 1988; Rothenberger, Chang & Cable, 1988). Francis et al. (1985) surveyed 135 instructors 96% of whom were female and found that 76.3% had suffered an injury related to aerobic dance. In this sample the most common site of injury was the shin and the average weekly class attendance was 7.1 times per week. Richie et al. (1985) included instructors (n = 58) and participants (n = 1233) and found a similar prevalence of injury (75.9%) in the instructor group and 43.3% in the participants. Again, shin pain was the most commonly reported injury and the authors reported a clear association between the overall injury rate and an increase in the frequency of weekly participation. Vetter et al (1985) observed injury patterns in 61 female aerobic dance instructors and participants attending a sports injury clinic, with 43 of that group completing an additional survey. The most prevalent injury in this group was foot pain and the average weekly attendance was 7.2 hours per week for instructors and 2.8 hours for participants. Mutoh et al. (1988) conducted a retrospective survey of 161 instructors and 800 participants over a five year period. The authors of this study reported that instructors and participants sustained 0.17 and 0.15 injuries per 100 hours respectively with a prevalence rate of 72.4% (instructors) and 22.8% (participants). Similar to the previously mentioned studies, the most common site of injury was the lower leg for instructors and the foot for participants. The frequency of participation in this study was slightly lower than those mentioned previously with instructors attending four to five classes per week while participants completed one to two classes. Rothenberger et al. (1988) surveyed 726 aerobic dancers (84% female) and observed an injury prevalence of 49% for the group. Once again shin and ankle injuries featured prominently (24.5% and 12.2% respectively) along with the lower back (12.9%). Training volume had a significant effect on injury prevalence in this group, with those attending aerobic dance classes less than four times per week being injured 43% of the time and those over 4 times per week recording an injury prevalence of 66%.

A 16 week prospective telephone survey of 60 instructors by Garrick, Gillien and Whiteside (1986) (80% female) and 351 participants (86.6% female) revealed a 48.7% and 75% prevalence of injury in participants and instructors respectively. The rate of injury in this survey was reported as 1.16 per 100 hours for participants and 0.93 for instructors, however, this rate jumped to 1.9 per 100 hours for those only doing aerobic dance classes for fitness. The authors in this study reported that increased time spent training was protective for the rate of injury with those only completing one class per week having twice the rate of those completing four classes. In terms of site of injury, similar patterns to those seen in the previous studies were observed, however, gender differences were noted with an increase in the number of foot injuries in males while females reported a significantly higher prevalence in the shin, knee and hip. Another prospective telephone survey was conducted in 1993 (Requa, DeAvilla & Garrick, 1993). Nine hundred and eighty six members of fitness clubs were recruited and monitored for three months. The authors were interested in injury rates in various fitness activities. Dance aerobics was the most commonly selected category with 83 % of those participating being female. The injury rates varied depending on the nature of the classes. Jazz funk classes had a rate of 19.47 and 12.03 injuries per 1000 hours of participation for all injuries and those resulting in time loss respectively. Other forms of aerobic dance (including high and low impact and step aerobics) had significantly lower rates with 4.98 per 1000 hours for all injuries and 3.81 per 1000 hours for those requiring time off from participation. Slightly lower rates were observed following a retrospective survey in Western Australia (Potter, 1996). This study recorded an injury rate of 0.23 per 100 hours over a 12 month period for those doing high impact aerobics. However, the average weekly attendance of this group (3.6 classes per week) was lower than the other studies mentioned thus far.

As aerobic dance progressed into the 1990's, a number of variations emerged in part to address some of the injury concerns observed above. Du Toit and Smith (2001) hypothesised that the introduction of low impact versions of aerobic dance, improved footwear and better instructor training would result in a reduced prevalence of injury. These authors recruited seventy participants and instructors (80% female) who returned surveys providing information on previous injuries (no time frame was stated in the report). The prevalence of injury was 77% (very similar to the aforementioned studies) with the leg and foot (including the ankle) being the most common sites of injury (52.9% and 32.8% respectively). In terms of frequency of teaching classes, 70% of the instructors taught an average of 7.8 classes per week, while 30% taught more than ten. Despite the continued high prevalence, 54.3% of those who sustained an injury did not require any time off from instructing.

With such a high weekly frequency of instruction outlined in these studies, one would assume that the accumulated levels of impact sustained while instructing aerobic dance would contribute to the reported prevalence of lower limb injuries. Lateral and vertical ground reaction forces were measured in female (n = 14) and male (n = 14) instructors as they performed low and high impact moves typically seen in aerobic dance classes (Rousanoglou & Boudolos, 2005). In both females and males, significantly higher vertical forces were observed in the high impact moves with a shorter time period to reach a force peak. The lateral forces exhibited no significant difference in the low impact moves, however, again, the time to reach a peak was significantly shorter in duration. In terms of gender difference, females were observed to have a significant increase in the amplitude of vertical ground reaction forces relative to body weight in the high impact measurements, while males had higher recorded lateral ground reaction forces.

These studies illustrate a high prevalence of aerobic dance injuries, particularly among instructors. There is also evidence of a high exercise volume in this group which may contribute to the extent of lower limb injuries outlined in this review.

2.4.2 Step Aerobics

The papers reviewed in this section were selected from a comprehensive Scopus, Medline, CINAHL and Sport Discus data base search from 1985 onwards. Papers were selected if they investigated injuries sustained by participants or instructors as a result of attending step aerobic classes. The first two papers investigate the injury prevalence of step aerobics participants and instructors. The remainder of papers explore the possible mechanisms which underlie these injuries.

Potter (1996) conducted a retrospective survey on 79 predominantly female instructors and participants (average age 29.1 years). The average weekly attendance of step aerobics classes was 3.9 classes per week with an average injury prevalence of 0.14 injuries per 100 hours. The most common site of injury was the knee (43.8% of reported injuries) followed by the calf (20.8%). A relationship was observed between step height and the frequency of injuries in participants, with an increase in step height resulting in a higher rate of injury. This relationship was not evident in instructors.

Malliou et al. (2014) conducted a three year prospective survey on 63 step aerobics instructors (male n = 24, female n = 39), average age 27.1 years. The average weekly attendance in this group was 9.3 hours per week with an average injury prevalence of 0.15 injuries per 100 hours. Over the three year period, 38.1% of instructors had one injury that required two days or more off teaching, 36% had two injuries and 26% had three. The ankle was the most commonly reported site of acute injury, while the knee and ankle were equally represented in chronic injuries. Step height and instructing hours were deemed to be the most significant contributors to injury incidence.

A number of papers have investigated the ground reaction forces and joint loads experienced during some of the more common step aerobics movement patterns and the association of these forces with step height. Maybury and Waterfield (1997) observed significant increases in peak impact force between six and eight inch high steps and six and ten inch steps. There was no significant difference detected between the eight and ten inch steps. Hsieh, Wu, Li and Wang (2009) observed significant increases in axial and shear forces in the lower limb when instructors moved from low impact to high impact moves. Rutkowska-Kucharska, Wysocka, Winiarski, Szpala, and Sobera (2017) observed discrepancies in joint loading between instructors and participants. Instructors demonstrated greater knee joint angles when performing a basic step exercise, while participants demonstrated greater foot adduction and ankle dorsiflexion resulting in increased ankle loading.

Willett, Karst, Canney, Gallant and Wees (1998) compared EMG readings of forward and backward stepping patterns commonly included in step aerobics on a step bench with the same movements performed on a step ergometer. Thirteen volunteers (4 male, 9 female) demonstrated significant differences in muscle readings with a reduction in output from vastus lateralis and vastus medialis and an increase in biceps femoris activity when exercising on the step bench.

In summary, despite benefits gained in strength and aerobic fitness (Kravitz, Wilmerding & Stolarczyk, 1994) there appears to be significant injury risk associated with regular participation in step aerobics. Factors such as step height, level of impact and frequency of classes have been demonstrated to have a significant effect on the prevalence of injury. The knee and ankle appear to be most commonly affected joints.

2.4.3 Injury Incidence in Cardio Kickboxing

The paper reviewed in this chapter was selected from a comprehensive Scopus, Medline, CINAHL and Sport Discus data base search from 1985 onwards. Papers were selected if they investigated injuries sustained by participants or instructors as a result of attending cardio kick boxing classes. One study (Romaine, Davis, Casebolt and Harrison, 2003) was found which investigated the rate of injury in kickboxing class instructors and participants.

Romaine et al. (2003) received surveys from 441 cardio kickboxing instructors and 129 participants. Sixty five percent of the respondents were female with an average age of 32.9 years. An injury due to participation in cardio kickboxing classes was reported by 29.2% of the subjects with a rate of 31% in instructors and 15.5% in participants. The most common location of injuries were the back (20%) followed by the knee (18%) and the hip (11%) for the group. Music speed had a significant relationship with the frequency of injury. Those who regularly completed classes with music faster than 140 bpm had an injury rate of 48%. Those who exercised to music speeds between 125 – 140 bpm had an injury rate of 32%. Although no average frequency of weekly classes was reported, there was an association between weekly attendance and injury. Of those who attended four or more classes per week 43% recorded injuries compared to 34% who completed up to 3.5 classes per week and 26% for up to 2.5 classes.

Cardio kickboxing classes have been demonstrated to improve cardiovascular fitness (Greene, Kravitz, Wongsathikun & Kemerly, 1999). Despite the fact that the recorded injury rate was lower than those reported in the aerobic dance category, significant injury risk is evident with factors such as weekly attendance and music tempos having a relationship with the rate of recorded injuries.

2.4.4 Injury Incidence in Yoga

The papers reviewed in this section report on the prevalence, rates and common sites of injury sustained during yoga classes. Yoga was included in this review as a large percentage of group fitness instructors reported attending yoga classes as a means of addressing flexibility needs. In addition, many gyms include yoga based programs on their group fitness timetables. Yoga classes were grouped into the flexibility component of the training history reported by the instructors in this investigation. Studies were selected if they investigated injuries sustained by participants or instructors as a result of attending yoga classes.

Table 2. Injury studies on yoga classes

Study	Study Design	Participants	Injury Prevalence / Rate	Most Common Site of Injury	Frequency of Classes
Mikonnen (2008)	Retrospective survey	110 participants 72% female Average age 35.9 years	1.18 injuries per 1000 hours 62%	Hamstring, Knee	3.59 classes per week
Penman (2012)	Retrospective survey	2,567 participants 85.5% female Average age 41.4	2.4%	Not stated	Average 1 – 2 classes per week
Holton (2014)	Retrospective survey	2230 yoga participants	Less than 1% reported discontinued practise due to injury	Back	Not stated
Swain (2014)	A and E attendance records	81.4% female	17.01 per 100,000 participants	Trunk	Not stated
Russell (2014)	A and E attendance records	66 individuals Average age 19 73% female	Not stated	Knee	
Park (2015)	Retrospective survey	162 Instructors 380 participants Average age 44 88.9% female	11.3% participants 17.1% instructors	Not stated	Not stated
Campo (2017)	Prospective Survey	354 participants 94% female Average age 45.7 years	10.7%	Not stated	Average 3.1 hours per week

Four studies conducted retrospective surveys (Holton & Barry, 2014; Mikkonen, Pederson & McCarthy, 2008; Park, Riley, & Braun, 2016; Penman, Cohen, Stebens & Jacklson, 2012). Mikkonen et al. (2008) surveyed 110 Ashtanga Vinyasa yoga practitioners. Of the 31 male and 79 female respondents (average age 35.9 years) 62% reported having at least one injury of more than one month's duration. However, some of these injuries were incurred prior to starting yoga practise. The injury rate for this group was calculated at 1.18 per 1000 hours of yoga practise when these types of injuries were excluded. Other retrospective studies reported lower injury rates. Penman et al. (2012) conducted a national survey of yoga practitioners in Australia. Of the 2,567 respondents (85% female, average age 41.4) only 2.4% reported a yoga related injury in the previous 12 months. The practise most commonly associated with injury was headstands (7.4% of sustained injuries). Holton and Barry (2014) examined data from the 2007 National Health Interview Survey in the USA. Of the 2,230 individuals who reported practicing yoga at any stage of their life, less than 1% described any side effects that resulted in discontinuing their practice. Park et al. (2016) conducted a survey on 542 yoga practitioners including 162 teachers (average age 44 years and 88.9% female). Teachers were more likely to report a higher percentage of negative effects with an injury prevalence of 17.1%.

Two studies reported on the incidence of yoga related injuries in Accident and Emergency departments. Swain and McGwin (2016) collected data from the National Electronic Injury Surveillance System in the US from 2001 to 2014. They then used the National Health Statistics Reports to estimate the number and age distribution of yoga participants nationally. Of the 29,590 yoga related injuries that attended Accident and Emergency departments between 2001 to 2014, 81.4% were female and 53.2% were aged between 18 and 44. Injuries to the trunk accounted for 46.6% of reported visits followed by the lower limb (21.9%). The authors estimate that 17.01 injuries were reported per 100,000 yoga participants in 2014, which was an increase from 9.55 in 2001.

Russell, Gushue, Richmond, and McFaull, (2016) reviewed data from the Canadian Hospitals Injury Reporting and Prevention Program between 1991 and 2010. Sixty six individuals who sustained 67 injuries were included in the review (73% female, average age 19). The most common type of injury was a sprain with the lower extremity reported as the most common site (41%).

Campo, Shiyko, Kean, Roberts, and Pappas (2017) sought to examine the relationship between musculoskeletal pain and recreational yoga participation via a one year prospective study. Of the 354 participants (94% female, average age 45.7) 10.7% reported pain caused by yoga during the 1 year period. Fifteen participants (4.2%) reported lost time from yoga as a result of these injuries and 5.4% reported pain that occurred during class.

It would therefore appear that, apart from the study by Mikkonen et al. (2008) which included injuries experienced prior to participating in the study, yoga practitioners and instructors have a relatively low rate of injury. As a result, yoga practise may be considered as a low risk means of maintaining and improving flexibility in group fitness instructors.

2.4.5 Injury Incidence in Indoor Cycling Classes

This section reviews papers that describe the prevalence of injuries sustained during indoor cycling. Papers were selected if they investigated injuries sustained by participants or instructors as a result of attending indoor cycling classes. A summary of each study can be found in Table 3.

Table 3. Injury studies on indoor cycling classes

Study	Study Design	Participants	Injury Prevalence / Rate	Most Common Site of Injury	Frequency of Classes
Hernandez-Contreras (2015)	Retrospective review	11 patients Average age 27.6 years 54% female	Not stated	Thighs	Not stated
Ramme (2016)	Case Studies	3 patients 2 female Average age 26 years	Not stated	Thighs	Not stated
Kim (2016)	Retrospective review	13 patients Average age 25.7 years 92.3% female	Not stated	Thighs	Not stated
Lubetzki-Vilnai (2009)	Retrospective Survey	457 health club attendees Average age 28.6 years 50.5% female	Not stated	Knee	2.9

Three papers have investigated the onset of rhabdomyolysis in novice indoor cycling participants. Hernandez-Contreras et al. (2015) conducted a retrospective review of patients who attended the Short Stay Unit, Internal Medicine Department Virgen de la Arrixaca University Hospital, Murcia, Spain from January 2012 to April 2013. Eleven patients (54% female, average age 27.6 years) attended the clinic for management of rhabdomyolysis in the thigh region following an initial session of indoor cycling. Ramme, Vira, Alaia, Van De Leuv and Rothberg, (2016) describes three cases of rhabdomyolysis admitted to New York University Hospital following an initial spinning class in two female and one male participant (average age 26 years).

Kim, Ham, Na, Lee, and Choi (2016) reviewed medical records of patients admitted to the Chungnam National University Hospital in Korea between 1 September 2011 and 30 April 2015 for management of rhabdomyolysis. Of the 70 patients included in the review, 13 (18.6%) were deemed to have symptoms related to spinning classes. The mean duration of spinning prior to admission was 59.2 minutes. Twelve of these patients were female with an average age of 25.7 years.

Lubetzky-Vilnai, Carmeli, and Katz-Leurer (2009) conducted a retrospective survey on 457 health club attendees (average age 28.6 years, 50.5% female). The overall injury rate for all respondents over the preceding 12 months was 41.6%. Participation in spinning classes doubled the probability of reporting a lower limb injury (OR = 1.9) and nearly tripled the probability of a knee injury (OR = 2.8). A higher frequency of classes was related to the prevalence of knee injuries.

2.4.6 Injury Incidence in Instructors Teaching Multiple Programs

This section reviews papers that describe the prevalence of injuries sustained by group fitness instructors teaching multiple programmes. Papers were selected if they investigated injuries sustained by group fitness instructors teaching two or more programs. A summary of each study can be found in Table 4.

Table 4. Injury studies on group fitness instructors teaching multiple programmes

Study	Study Design	Participants	Injury Prevalence / Rate	Most Common Site of Injury	Frequency of Classes
Potter (1996)	Retrospective Survey	59 Instructors Average age 32.8 years	37% over 12 months 0.18 per 100 hours	Ankle, foot	8.3 classes per week
Malliou (2013)	Retrospective and Prospective Survey	273 Female Instructors Average age 28 years	57.1% 0.18 injuries per year	Leg	Not stated
Bratland-Sanda (2015)	Retrospective survey	837 Instructors 81.8% female Average age 33.7 years	47% lifetime	Ankle	2.9 hours per week

Potter (1996) conducted a retrospective survey on 59 group fitness instructors from Western Australia. Specifically, the questionnaire was designed to gain information on the incidence, site and severity of injury in relation to class type and other environmental factors. More than two thirds of the instructors who responded taught a combination of step classes, high impact aerobics and low impact classes with an average weekly frequency of 8.3 classes per week. Thirty seven percent reported at least one injury in the previous 12 months with an injury rate of 0.18 injuries per 100 hours. One third of the instructors reported that the injury was sustained during a class. The ankle and foot were the most common sites of injury overall, however, the incidence of knee injuries increased in those teaching step classes only. Those instructors who sustained an injury missed an average of nine classes over a 1.5 week period. Overexertion and increased frequency of attendance were found to be significant factors related to the reporting of an injury.

Malliou, Rokka, Tsiganos, Mavromoustakos, and Godolias (2013b) and (2013a) undertook a six month retrospective and three year prospective survey on 273 female group fitness instructors (average age 28) in Greece. The injury rate for the group was 0.18 injuries per instructor per year with 57.1% of the instructors encountering an injury. The most common location when acute and chronic injuries were combined was the knee followed by the leg and back (25.3%, 23.7% and 22.1% respectively). The authors noted that the rate of injury was positively associated with hours spent instructing, intensity of classes and instructing more than one style of class.

Bratland-Sanda, Sundgot-Borgen, and Myklebust (2015) surveyed 837 Norwegian instructors (81.8% female, average age 33.7 years) and found that 47% had suffered at least one injury over the course of their group fitness career. The ankle was the most common site of acute injury while the lower leg was the most prevalent location for overuse injuries. This group also found that volume of instruction was associated with injury rates. Those instructors who taught more than five hours per week reported a significantly higher prevalence of acute and overuse class related injuries. A logistic regression analysis showed that hours per week instructing, hours per week spent instructing high impact classes, years working as an instructor and total eating disorder inventory scores were factors associated with instruction-related injuries.

Garnham, Finch and Salmon (2001) reviewed papers investigating injury incidence across a variety of group fitness classes published between 1975 and 2000. Information from the eight papers included for review described an injury rate for group fitness instructors ranging from 1.7 to 2.9 injuries per 1000 hours. The lower leg was deemed to be the most common location of injury. The authors noted that injury rates in instructors have been shown to be lower than those recorded in the participant group (1.5 to 10.1 per 1000 hours). They also described an increase in the prevalence of knee and calf injuries with the introduction of step aerobics.

2.5 Risk factors and Injury Incidence

A search of the literature was conducted for risk factors influencing the incidence of musculoskeletal injury. The Scopus, Medline, CINAHL and SPORTDiscus databases, to 1st July 2017 were searched for terms linked with the Boolean operators: "Musculo* Injur*" AND "risk factors". Papers were selected based on title, then abstract and finally text. Manual searching of reference lists was used to identify additional articles. Papers were excluded if their content: (i) was unavailable in English; (ii) was unavailable in full text format; (iii) did not provide additional information for any of the identified sections and subsections of this review. Inclusion criteria for all articles were: (i) cross sectional studies or surveys (ii) reported data for injury incidence per 1000 / 100 hours and injury rate ratios.

2.5.1 Age

The papers reviewed in this section report on the influence of age on the incidence of injury across a variety of training conditions. The findings are summarised in Table 5.

Table 5. The effect of age on injury incidence

Author	Sample	Effect of Age on Injury Rate
Jacobs (1986)	Entrants to a 10,000m run	No age difference between injured and non-injured
Rothenberger (1988)	Aerobic dance participants	Younger subjects reported increased injury incidence
Jones (1993)	Military basic training recruits	Older subjects have a higher risk of injury than younger subjects
Knapik (1993)	Members of an infantry battalion	Proportion of those injured decreased as age increased
Heir (1996)	Male military conscripts	Increased injury rates in older age group
Taunton (2002)	Patients with running injuries attending a sports medicine clinic	The effect of age is injury specific
Keogh (2006)	Power lifters	Injury rates similar in Open versus Masters lifters
Roy (2014)	Female soldiers serving in garrison units	Significant correlation between older age and injury

Two studies reported on the effect of age on running injuries (Jacobs & Berson, 1986; Taunton, Ryan, McKenzie, Lloyd-Smith & Zumbo, 2002). Jacobs and Berson, (1986) conducted a retrospective survey on 451 entrants to a 10,000 metre race (355 men and 96 women). Forty seven percent had suffered an injury in the two year period prior to filling out the survey. There was no significant difference in age between the injured and non-injured in this sample. Taunton et al. (2002) reviewed data of 2002 patients (54% female) who attended a Sports Medicine Clinic in British Columbia. The authors found that patients who were younger than 34 years had a higher rate of patella femoral pain in both sexes and iliotibial band friction syndrome, patellar tendinopathy, and tibial stress syndrome in men. In contrast meniscal injuries were less common in this age group for both sexes, while plantar fasciitis and Achilles tendinopathy were less frequent in men.

Rothenberger et al. (1988) reported on the incidence of injury in 726 males and females participating in aerobic dance classes. The authors found that younger subjects (aged less than 40) recorded more injuries than older subjects. The most common site of injury varied with age. The younger age groups reported the shin as the most common injury location, while the lower back was recorded more frequently in the older subjects.

Four studies reported on the relationship between age and injury in military recruits (Heir & Eide, 1996; Jones et al., 1993; Knapik, Ang, Reynolds & Jones, 1993; Roy et al., 2014) . Three studies reported evidence of increasing incidence of injury with age. Jones et al. (1993) monitored 303 males attending army infantry basic training over a 12 week period. These authors found that the relative risk of sustaining a lower limb injury for individuals who were older than 24 years was greater than those who were younger than 19 years. They also noted a statistically significant trend of increasing risk with increasing age across the group. Heir and Eide (1996) investigated the relationship between age and injury incidence in 912 male conscripts in the Norwegian armed forces. This investigation found there was a significantly higher rate of injury in recruits over the age of 23 than what was reported in the younger age groups. Roy et al. (2014) retrospectively surveyed 625 women serving in garrison Army units to determine injury incidence over a 12 month period. These authors found a significant correlation between older age and musculoskeletal injury.

In contrast Knapik, Ang, Reynolds and Jones (1993) examined the injury incidence in 298 male soldiers assigned to an infantry battalion in Alaska. Data collected over a six month period indicated that the proportion of soldiers injured decreased as age increased.

Thacker et al. (2000) reviewed military and civilian studies to determine which factors increased the risk of exercise-related injury in women. The authors found inconsistent findings across both types of studies. Their conclusion was that data from injury incidence studies imply that among adults aged <45 years, age alone is not a strong predictor of exercise-related injury.

Keogh, Hume, and Pearson, (2006) examined the injury incidence of 82 men and 19 women power lifters. This investigation found that lifters in the Masters category had a similar rate of injury as those in the Open category. The authors noted that the difference in training experience of the older group may have offset any extra risk of injury.

2.5.2 Gender

The papers reviewed in this section report on the influence of gender on the incidence of injury across a variety of training conditions. The findings are summarised in Table 6.

Table 6. The effect of gender on injury incidence

Author	Sample	Effect of Gender on Injury Rate
DeHaven (1986)	3431 patients treated at Sports medicine Clinic	Patellofemoral pain and dislocation more common in females
Taunton (2002)	2 year retrospective study on 2002 clinical records of running injuries	Females reported higher rates of Patellofemoral pain syndrome, I-T band friction syndrome, gluteus medius and sacroiliac injuries. Males reported a higher rate of plantar fasciitis, meniscal injuries, patella tendonitis, osteo arthritis of the knee, adductor and Achilles injuries.
Hootman (2002)	1 year retrospective injury survey of 6,311 adults	No gender differences in anatomical site or rate of all-cause and activity related injuries.
Keogh (2006)	1 year retrospective study of power lifters	No gender differences in rates of injury. Males had a higher prevalence of chest and knee injuries.
Lubetzky-Vilnai (2009)	1 year retrospective survey of sports centre attendees	Males reported higher injury rates. Males who undertook weight training reported a higher incidence of upper limb injury. Females who undertook spinning classes had a higher incidence of knee injuries
Buist (2010)	8 week prospective study of recreational runners	Males had a higher incidence of injury. Younger age increased risk in males. Higher BMI increased risk in females
Moran (2017)	12 week prospective study on CrossFit participants	Males were more likely to sustain an injury than females

Two studies found no significant difference in injury rates with respect to gender. Three found that males had a higher rate, while 2 studies found that gender differences were specific to different types of injuries.

Hootman, Macera, Ainsworth, Addy, Martin and Blair (2002) conducted a retrospective survey of adults enrolled in the Aerobics Center Longitudinal Study in Texas. Injuries over a 12 month period were reported and correlated to baseline assessment data. Of the 6,311 respondents, 20.0 % of females and 20.3% of males reported an activity related injury. No significant differences were observed in anatomical sites or rates of injuries. Keogh et al. (2006) investigated injuries in 82 male and 19 female power lifters. Again, no significant differences were observed in the prevalence of injury in males and females.

In contrast, Lubetzky-Vilnai et al. (2009) conducted a one year retrospective training history and injury survey, collecting data from 457 men and women belonging to sports centres in Israel. Training differences were observed with men participating in weight training more often than women, while women were more likely to attend aerobics sessions. The rate of injury per 100 hours of exercise was higher for men (34.9) than women (14.7). Men reported more upper extremity injuries while women reported more injuries of the lower extremity. Similarly, Buist et al. (2010) investigated the incidence and sex-related predictors of injuries in a group of recreational runners training for a 4 mile running event over an 8 week period. Data from 207 men and 422 women was analysed to reveal a significantly higher incidence of injury in males (31.4% versus 23.2% in females). In addition, Moran, Booker, Staines, and Williams (2017) conducted a prospective study of 117 CrossFit participants (66 males, 51 females) over a 12 week period. They found that despite a relatively low injury rate, males were significantly more likely to suffer an injury than females.

Finally, two studies found gender differences to be injury specific. DeHaven and Linter (1986) reviewed clinical records of 3431 patients attending the Rochester Section of Sports Medicine clinic over a seven year period. Males accounted for 80.3% of all injuries with sprains and strains being the most common type injury for both groups. Gender differences were noted in the types of injuries recorded with more females attending the clinic for patellofemoral pain than males (19.6% of all injuries for females compared to 7.4% for males). Similar findings were noted for patella dislocation which accounted for 4.6% of the injuries in females versus 0.7% in males. Taunton et al. (2002) found differences in the anatomical site of injuries following a review of the records of 2002 patients reporting to the Allan McGavin Sports Medicine Centre in British Columbia over a two year period. Patellofemoral pain syndrome, iliotibial band friction syndrome, gluteus medius and sacroiliac injuries were all more common in the female group. In contrast, males reported a higher rate of plantar fasciitis, meniscal injuries, patella tendonitis, osteo arthritis of the knee, adductor and Achilles injuries.

In summary, there are mixed findings on the effect of gender on injury risk. Therefore, the findings of the current study will be of prime importance in determining gender specific recommendations for injury prevention in group fitness instructors. Establishing site specific injury trends in both groups along with the effects of different training methods will be of great value in establishing preventive exercise protocols.

2.5.3 Training Load

A search of the literature was conducted for reports on the relationship between training load and the incidence of musculoskeletal injury. The Scopus, Medline, CINAHL and SPORTDiscus databases, to 1st July 2017 were searched for terms linked with the Boolean operators: “training load” AND “injur*”. Papers were selected based on title, then abstract and finally text. Manual searching of reference lists was used to identify additional articles. Papers were excluded if their content: (i) was unavailable in English; (ii) was unavailable in full text format; (iii) did not provide additional information for any of the identified sections and subsections of this review. Inclusion criteria for all articles were: (i) cross sectional studies or surveys (ii) reported data for injury incidence per 1000 / 100 hours and injury rate ratios. Two categories of papers were included: papers that described the effects of training load on group fitness injuries and review articles. The findings are summarised in Table 7 below.

Table 7. The effect of training load on injury incidence

Author	Description	Effect of Training Load on Injury Rate
Richie (1985)	Retrospective injury survey of 1233 aerobic dance participants and 58 instructors	Those who were injured participated more times per week.
Rothenberger (1988)	Retrospective injury survey 726 aerobics participants	Participants who attended less than four classes per week reported fewer injuries compared to those who attended four or more.
Malliou (2014)	Prospective 3 year injury survey 63 step aerobic instructors	Working days per week was a significant predictor of days taken off instructing due to injury.

Three studies investigated the relationship between training load and injury in a group fitness environment (Malliou et al., 2014; Richie et al., 1985; Rothenberger et al., 1988). Richie et al. (1985) conducted a retrospective injury survey on 1233 aerobic dance participants and 58 instructors. When comparing the frequency of classes of injured participants versus non-injured, it was found that the injured group were participating significantly more than the non-injured group on a weekly basis. They also reported that instructors had a significantly higher weekly attendance than students (3.3 and 4.7 times per week respectively) and as a result, instructors reported more injuries (75.9%) than the student group (43.3%). Rothenberger et al. (1988) conducted a retrospective injury survey on 726 aerobics participants. Those who participated in fewer than four classes per week reported significantly fewer injuries (43%) compared to those who participated in four classes (60%) or more (66%). Malliou et al. (2014) conducted a three year prospective injury survey on 63 step aerobic instructors. Regression analysis revealed that "working hours per week" was a significant predictor of days taken off from instructing due to injury.

Four review articles exploring the relationship between training load and injury describe similar findings (Drew & Finch, 2016; Jones, Griffiths, & Mellalieu, 2017; Saragiotto et al., 2014; Thacker et al., 2000). A review on exercise related injuries in women (Thacker et al., 2000) describes a dose response relationship between volume of weight bearing exercise and injury rates. This review also reported on military studies. Again, injury rates were observed to increase as mileage and duration of training increased. Saragiotto et al. (2014) conducted a review of prospective cohort studies investigating risk factors of running related injuries. This review describes two papers that observed a relationship between running mileage and injury rates and two articles that describe a relationship between running frequency and injury rates. Drew and Finch (2016) reviewed 25 studies to determine the relationship between training and competition load and injury, illness and soreness. The authors state that there is moderate emerging evidence of a relationship between athletic training load and the risk of injury. Evidence for the relationship of training load to illness is conflicting although overall a moderate relationship between the variables is described. The relationship between training load and soreness was less well defined. Finally, Jones et al. (2017) reviewed 68 articles reporting relationships between training load and fatigue measures and injury and illness in athletic populations. They report moderate evidence of a relationship between training load and injury particularly related to periods of training load intensification. Articles investigating changes in acute training load and injury revealed a varied relationship with injury while chronic or accumulated load was seen as a significant factor in terms of injury management.

Training load will be a key variable when monitoring injury rates in group fitness instructors. Internal instructor surveys conducted by Les Mills International indicate that there is a range of weekly training hours in this group with some being part time while others who teach fitness classes for a living having a much higher volume. It will therefore be pertinent to establish guidelines on how to manage different loads.

This section explored risk factors associated with injury incidence. There are mixed findings on the effect of age and injury incidence, a strong indication that there is a difference in the location of injuries according to gender but not overall injury incidence and finally there is a moderate to strong indication that training load is related to the incidence of injury.

The next chapters will aim to establish how these various factors affect the Les Mills instructor population. No studies have been conducted to investigate these relationships in this particular group. Utilising this information to establish best practise recommendations for injury prevention will assist the Les Mills organisation in educating instructors on injury prevention, particularly in light of some of the high injury rates in comparable groups mentioned in this review.

Chapter 3 Methods

3.1 Introduction

The need to role model the often high levels of physicality in group fitness classes, in many cases multiple times daily, places instructors at high risk of injury. No previous study has been conducted on the specific factors that influence the onset of injury in group fitness instructors who teach a variety of class formats.

The purpose of this study is to investigate the relationship between age, training history and incidence and intensity of pain and injury in the spine and lower limb in Les Mills group fitness instructors via retrospective data analysis. In the current study, the sample of interest were Les Mills group fitness instructors from the USA, United Kingdom, Australia and New Zealand and a self-reported six-month injury history collected via electronic survey.

A survey to investigate injury rates related to each of the Les Mills programmes was designed by Les Mills International and Dr Jinger Gottschall of Penn State University. The data from 3,400 anonymous respondents was received by Dr Gottschall for analysis. A brief description of injury rates for each of the programmes was produced and a summary of the findings was sent to Les Mills International.

Les Mills International subsequently granted consent for the information from the survey to be analysed for the purpose of investigating whether any associations between age, training habits and recorded pain and injury could assist with injury prevention strategies for Les Mills instructors worldwide. A formal letter was received by Dr Jackie Mills (Chief Creative Officer) granting full access to the database. The raw data from the initial investigation was then sent to the author in Excel format for secondary analysis. Conversion to SPSS was undertaken to enable statistical analysis.

3.2 Study Design

A cross-sectional study via electronic survey.

3.3 Subjects

Subjects were certified Les Mills group fitness instructors registered to the USA, United Kingdom, Australia / Asia Pacific and New Zealand offices. A description of the survey along with a link to the questionnaire was included in an electronic newsletter sent to instructors by each regional office.

3.4 Survey

A link to a Qualtrics electronic survey was included in each newsletter. A consent description was included in the email (see appendix). An ethics application for secondary analysis of the data was sent to the Auckland University of Technology Ethics Committee. As the data was anonymous and the participants had granted consent to future use of the data, ethics approval was not required.

Participants in the survey were asked to provide information on age and gender along with their country of residence. They were also asked to record the type of training undertaken on a regular basis as well as how often they trained in each modality. Overall training load was captured on a 4 point scale of 1 – 5 hours, 6 – 10 hours, 11 – 15 hours or more than 15 hours. A description of which Les Mills programmes they taught or attended each week and the frequency was captured in more detail. The respondents also provided information on other types of training they did outside of the Les Mills programmes.

Participants were then asked to describe whether or not they had suffered pain in each region of the body and which training activities they thought were the major contributor. Timing of injuries was classified as chronic (present for longer than 6 months) either before or after they began teaching as a Les Mills instructor, or acute if an isolated event occurred in the last 6 months, or none of the above if they hadn't encountered an injury in the previous 6 months. Descriptions of the intensity of their recorded injuries were determined by the following options, mild (no change in training), moderate (more than one day of unplanned rest resulting from the injury), severe (over one week of unplanned rest with a physician visit) or none of these options if they hadn't encountered any pain. In each of these scenarios an "injury" was defined as pain or stiffness related to fractures, muscle tears, sprains, strains, ruptures or severe bruises. These definitions and classifications were based on the National Collegiate Athletic Association Injury Surveillance System and National Athletic trainers Association Injuries Guidelines (Hootman, Dick, Agel, 2007; Vetter, Symonds, 2010).

3.5 Statistical Analysis

The data received from Dr Gottschall was received in Excel format and was converted to SPSS and checked for incomplete responses which resulted in a reduction to 3,208 eligible responses. The following steps were undertaken by the author to enable the investigation of the relationship between age, training history and incidence and intensity of pain and injury in the spine and lower limb of the respondents.

Some variables were recoded to enable analysis via logistic regression. The frequency of symptoms associated with each body part were ascertained by describing whether symptoms were felt on a scale of never, occasionally, daily or currently. As this scale cannot be considered ordinal (due to the lack of distinction between daily and currently) these responses were grouped into a binary format with never as “no” and occasionally, daily and currently as a “yes” response. Injury intensity was also recoded into a binary response by classifying mild (no change in training), and none of the above (no pain) as a negative response and moderate (at least one day of unplanned rest) and severe (over one week of unplanned rest) as a positive response.

Some body regions were also recoded for analysis. Neck, thoracic and lumbar regions were analysed separately and also grouped to create a spinal pain category to enable recommendations on “spinal care” in the resulting education material. Symptoms listed as knee anterior and knee outer were combined as knee pain. Hip inner and outer were regrouped as hip pain. Finally, shin, ankle calf-Achilles and foot pain were combined to create a foot - shin pain group.

Specific training modalities were also combined. A positive response to weekly participation in BODYBALANCE (a Les Mills yoga, Pilates fusion class), Yoga or a dedicated stretching session was classified as flexibility training. Similarly a positive response to weekly attendance to either BODYATTACK, BODYSTEP, GRIT (Les Mills programmes that are deemed high impact as they consist of a significant amount of movement patterns consisting of a flight phase where both feet leave the ground (Rousanoglou & Boudolos, 2005), high intensity interval training such as Tabata, cross fit or insanity were combined to form a high impact group. Regular attendance to either BODYPUMP (a Les Mills resistance training class), weight training or strength training were classified as a strength training group.

A Pearson Chi-Square analysis was performed to analyse the association between gender and the descriptive statistics along with recorded pain in each region and intensity of injury.

Descriptive analysis of each body region was conducted to provide an overview of the amount of participants in each age and training volume group and whether or not they undertook core, flexibility, strength or high impact training. The frequency counts and percentages who had recorded symptoms in each region was cross referenced with the above groups. The same analysis was undertaken for injury intensity.

Binary logistic regression was performed to analyse the relationship with pain described in each region and the factors listed above. Those factors that had a p-value of 0.2 or less were then included in a stepwise regression model building process. Finally, all factors that demonstrated a probability of less than 0.05 resulting from the stepwise analysis were then included as a group in a final logistic regression. The training factors that demonstrated a significant relationship ($p<0.05$) in this final analysis were deemed to contribute to the best model of predictors of injury in each region.

Chapter 4 Results

4.1 Introduction

This chapter is divided into three sections. The first section outlines the demographics of the subjects who participated in the survey, the second section highlights the best predictive models based on logistic regression for males and females who recorded any pain over the six-month period prior to receiving the survey, followed by pain recorded in each body region. The final section presents the results of the best predictive model for injury intensity, again comparing male and female data. Each analysis explores the effects of age, training volume, and regular participation in core, flexibility, strength or high impact training.

4.2 Subjects

Estimates from the regional Les Mills offices indicate that 46,243 instructors received the email with the link to the survey. A total of 3,208 participants were included in the final data set. Males made up 594 of the sample with 2614 females.

Table 8. Summary of Survey Participants - Gender

Gender	Frequency	Percent
Male	594	18.5
Female	2614	81.5

The response rates to the survey were low and varied with different regions. Values ranged from 12% in the Asia Pacific to 5% in the USA and 3% in the participating European teams.
The majority of participants were aged between 31-40 years (37.5%) with the largest group from the Asia Oceania region and the USA (43.7% and 42.9% respectively). Most of the respondents had been instructing or participating in Les Mills group fitness classes for over two years (83.7%) with 6.1% having achieved an elite instructor (trainer) status. The majority reported regularly exercising for six to ten hours per week (52.5%) while a further 31.2% train for more than 11 hours per week.

The descriptive characteristics of this cohort, separated by gender, can be found in Table 9. Chi square analysis revealed significant differences ($p<0.05$) of age, with more females in the older age groups; geographic region, with more females from the USA and European regions; time spent attending Les Mills classes, females had spent more time participating in Les mills classes and less females had gone on to trainer level (elite status). There was no significant difference in exercise volume between the two groups ($p>0.05$).

Table 9. Descriptive Characteristics of Survey Participants - Gender

		Females		Males		X^2
		n	**%**	**n**	**%**	
Age	**<30**	534	20.4	192	32.3	<0.01
	31-40	969	37.1	235	39.6	
	41-50	781	29.9	106	17.8	
	>50	330	12.6	61	10.3	
Geographic Region	**Asia Pacific**	1056	40.4	346	58.2	<0.01
	USA	1204	46.1	172	29.0	
	Europe	213	8.1	39	6.6	
	Other	141	5.4	37	6.2	
Years Doing Les Mills Classes	**0-2**	396	15.1	129	21.7	<0.01
	3-5	703	26.9	179	30.1	
	6-9	723	27.7	146	24.6	
	>10	792	30.3	140	23.6	
Instructor Level	**Elite (Trainer Level)**	140	5.4	54	9.1	<0.01
	Basic	2474	94.6	540	90.9	
Hours of Planned Exercise Per Week	**1-5**	417	16.0	108	18.2	0.24
	6-10	1394	53.3	290	48.8	
	11-15	550	21.0	132	22.2	
	>15	253	9.7	64	10.8	

A summary of the frequency of recorded pain, pain in each body region and injury intensity separated for females and males can be found in Table 10. A Pearson Chi-Square analysis indicates a significant association between gender and the recording of any pain, spinal pain, hip pain and injury intensity.

Table 10. Summary of reporting of pain by region and injury intensity for females and males

		Females		Males		X^2
		n	**%**	**n**	**%**	
Any Recorded Pain	**No**	106	4.3	40	7.3	<0.01
	Yes	2377	95.7	507	92.7	
Spinal Pain	**No**	428	16.4	123	20.7	0.01
	Yes	2186	83.6	471	79.3	
Lumbar Pain	**No**	1046	40.0	240	40.4	0.86
	Yes	1568	60.0	354	59.6	
Hip Pain	**No**	1564	59.8	413	69.6	<0.01
	Yes	1050	40.2	180	30.4	
Knee Pain	**No**	1103	42.2	254	42.8	0.78
	Yes	1511	57.8	339	57.2	
Lower Leg Pain	**No**	1222	46.8	281	47.4	0.79
	Yes	1391	53.2	312	52.6	
Injury Intensity (Unplanned day off)	**No**	1556	60.3	395	67.4	<0.01
	Yes	1025	39.7	191	32.6	

These gender differences in the demographics and injury profiles, along with the fact that over 80 percent of this cohort were female (which could potentially distort the results for the male group), generated the decision that it was necessary to examine the regional pain and injury intensity data separately for females and males.

4.3 Associates of Injury Outcomes

4.3.1 Any Recorded Pain

Data from each region of the body was combined to determine which participants had encountered any pain over the six month period prior to receiving the survey. Logistic regression was performed to investigate which variables (training volume, core, flexibility, strength and impact training and age) were associated with recorded pain in males and females.

Table 11 illustrates the relationship between training volume and whether female participants encountered any pain.

Table 11. Any recorded pain (Yes/No) in female participants

	n	% pain	OR	95% CI	p value
Training Volume - Hrs / Week					
1-5	417	95.4	1.00		0.01
6-10	1394	96.6	1.37	(0.79-2.36)	
11-15	550	96.4	1.27	(0.67-2.40)	
>15	253	92.1	0.56	(0.29-1.06)	

Training volume had a significant contribution as to whether the female group recorded pain ($p = 0.01$). No other factors had a significant relationship with any recorded pain in females or met the criteria for inclusion in the multiple variable model.

Flexibility and strength training were examined for the male group. Neither of these variables were found to have a statistically significant effect ($p < 0.05$).

Tables illustrating the relationships between all other variables and recorded pain in males and females can be found in Appendix C.

4.3.2 Spinal Pain

Training volume, core, flexibility, strength and impact training and age were examined for males and females to determine their relationship with spinal pain.

Table 12 illustrates the relationship between core and flexibility training and whether female participants encountered any pain in the neck, thoracic or lumbar regions of the spine.

Table 12. Spinal pain Yes / No in female participants

			Unadjusted			Adjusted		
	n	% pain	Odds Ratio (95% CI)		p value	Odds Ratio (95% CI)		p value
Core Training								
No	1543	85.0	1.27	(1.03-1.56)	0.03	1.29	(1.05-1.60)	0.02
Yes	1071	81.7	1.00			1.00		
Flexibility Training								
No	1313	81.4	0.72	(0.59-0.89)	0.002	0.71	(0.58-0.88)	0.001
Yes	1301	85.9	1.00			1.00		

Adjusted Odds Ratio – regression analysis including flexibility and core training as covariates

Table 13 illustrates the relationship between flexibility and strength training and whether male participants encountered any pain in the neck, thoracic or lumbar regions of the spine.

Table 13. Spinal pain Yes / No in male participants

			Unadjusted			**Adjusted**		
	n	**% pain**	**Odds Ratio (95% CI)**		**p value**	**Odds Ratio (95% CI)**		**p value**
Flexibility Training								
No	367	76.0	0.58	(0.38-0.89)	0.01	0.60	(0.39-0.93)	0.02
Yes	227	84.6	1.00			1.00		
Strength Training								
No	54	59.3	0.34	(0.19-0.60)	0.001	0.35	(0.19-0.63)	<0.001
Yes	540	81.3	1.00					

Adjusted Odds Ratio – regression analysis including flexibility and strength training as covariates

Flexibility training had a significant effect on spinal pain for both females and males ($p = 0.001$, $p = 0.02$ respectively) with the odds of reporting pain in those undertaking regular flexibility training increasing in both groups.

Core training had a significant effect in females, but not in males, with the odds of experiencing spinal pain in females reducing significantly ($p = 0.02$) with those who reported undertaking regular core conditioning. Participation in strength training was observed to significantly increase the odds of spinal pain in males ($p < 0.001$).

The relationships of other factors and their contribution to spinal pain in males and females can be found in tables in Appendix C.

4.3.3 Lumbar Pain

Training volume, core, flexibility, strength and impact training and age were examined for females and males to determine their relationship with lumbar pain.

Table 14 illustrates the relationship between core and flexibility training and whether the female participants encountered any pain in the lumbar spine.

Table 14. Lumbar Pain Yes / No in female participants

	n	% pain	Unadjusted Odds Ratio (95% CI)		Unadjusted p value	Adjusted Odds Ratio (95% CI)		Adjusted p value
Core Training								
No	1543	62.7	1.31	(1.12-1.54)	0.001	1.33	(1.14-1.56)	<0.001
Yes	1071	56.1	1.00					
Flexibility Training								
No	1313	57.6	0.82	(0.70-0.96)	0.01	0.80	(0.69-0.94)	0.006
Yes	1301	62.4	1.00					

Adjusted Odds Ratio – regression analysis including flexibility and core training as covariates

As observed in the analysis of spinal pain, regular participation in core conditioning is associated with a significant reduction in the incidence of reporting lumbar pain in the female group ($p < 0.01$), whereas, participation in flexibility training on a weekly basis significantly increased the odds of the respondents registering a positive response regarding lumbar pain ($p = 0.006$).

Table 15 illustrates the relationship between strength training and whether the male participants encountered any pain in the lumbar spine.

Table 15. Lumbar Pain Yes / No in male participants

	n	% pain	OR	95% CI	p value
Strength Training					
No	54	37.0	0.36	(0.20-0.65)	<0.001
Yes	540	61.9	1.00		

Only strength training was found to have a significant relationship ($p < 0.001$) in males with an increase in the odds of reporting lumbar pain in those who undertook regular strength conditioning. None of the other factors were observed to contribute to an improved model.

The relationships of other factors and their contribution to lumbar pain in both females and males can be found in tables in Appendix C.

4.3.4 Hip Pain

Training volume, core, flexibility, strength and impact training and age were examined for females and males to determine their relationship with hip pain.

Table 16 illustrates the relationship between flexibility training and whether the female participants encountered any pain in the hip region.

Table 16. Hip Pain Yes / No in female participants

	n	% pain	OR	95% CI	p value
Flexibility Training					
No	1313	37.9	0.83	(0.71-0.97)	0.02
Yes	1301	42.4	1.00		

Regular participation in flexibility training resulted in a significant increase in the reporting of hip pain in female participants (p = 0.02). No other factors had a significant relationship (p < 0.05) or met the criteria for inclusion in a Stepwise analysis.

Table 17 illustrates the relationship between flexibility training and frequency of BODYBALANCE classes and whether the male participants encountered any pain in the hip region.

Table 17. Hip Pain Yes / No in male participants

			Unadjusted			Adjusted		
	n	% pain	Odds Ratio (95% CI)		p value	Odds Ratio (95% CI)		p value
Flexibility Training								
No	367	26.7	0.64	(0.45-0.91)	0.01	0.39	(0.24-0.65)	<0.001
Yes	226	36.3	1.00			1.00		
BODYBALANCE Classes per Week								
0	444	30.4	1.00		0.32	1.00		0.02
1-2	101	25.7	0.79	(0.49-1.30)		0.38	(0.20-0.71)	
3-4	35	42.9	1.72	(0.85-3.46)		0.81	(0.36-1.81)	
>5	13	30.8	1.02	(0.31-3.36)		0.48	(0.14-1.69)	

Adjusted Odds Ratio – regression analysis including flexibility and frequency of BODYBALANCE classes as covariates

In the male group, training volume, flexibility training and frequency of BODYBALANCE classes were included for analysis with Stepwise regression to determine their relationship with the recording of hip pain. Regular participation in flexibility training was associated with a significant increase in reported hip pain (p < 0.01). A stronger predictive model was observed when frequency of participation in BODYBALANCE classes and flexibility training were included as covariates in a regression analysis. Both of these training variables had significant contributions in the reporting of hip pain in males with flexibility training significantly increasing the odds of reporting hip pain (p < 0.001) while regular participation in BODYBALANCE classes resulted in a significant decrease (p = 0.02).

The relationships of other factors and their contribution to hip pain in both females and males can be found in tables in Appendix C.

4.3.5 Knee Pain

Training volume, core, flexibility, strength and impact training and age were examined for females and males to determine their relationship with knee pain.

Table 18 illustrates the relationship between age and impact activities and whether the female participants encountered any pain in the knee region.

Table 18. Knee Pain Yes / No in female participants

			Unadjusted			**Adjusted**		
	n	**% pain**	**Odds Ratio (95% CI)**		**p value**	**Odds Ratio (95% CI)**		**p value**
Age								
<30	534	57.5	1.00		0.12	1.00		0.05
31-40	969	55.1	0.91	(0.73-1.12)		0.93	(0.75-1.15)	
41-50	781	60.7	1.14	(0.91-1.43)		1.20	(0.96-1.51)	
>50	330	59.4	1.08	(0.82-1.43)		1.16	(0.88-1.55)	
Impact								
No	902	53.9	0.78	(0.67-0.92)	0.003	0.76	(0.64-0.90)	0.001
Yes	1712	59.9	1.00			1.00		

Adjusted odds ratio: regression analysis including age and impact as covariates

Impact training and age had a significant relationship with recorded knee pain in the female group. Including these variables as covariates in a regression analysis produced the best predictive model with the odds of experiencing knee pain in those participating in impact activities significantly higher (p = 0.001) and being significantly influenced by age (p = 0.05).

Table 19 illustrates the relationship between core training whether the male participants encountered any pain in the knee region.

Table 19. Knee Pain Yes / No male participants

	n	**% pain**	**OR**	**95% CI**	**p value**
Core Training					
No	392	53.8	0.67	(0.47-0.94)	0.02
Yes	201	63.7	1.00		

Age, flexibility training and core training were examined for their relationship with knee pain in the male participants. Only core training was found to have a significant relationship with pain experienced in the knee region with the odds of reporting pain significantly increasing in those that undertook regular core conditioning classes. The other variables did not contribute to an improved model.

The relationships of other factors and their contribution to knee pain in both females and males can be found in tables in Appendix C.

4.3.6 Lower Leg Pain

Training volume, core, flexibility, strength and impact training and age were examined for females and males to determine their relationship with lower leg pain.

Table 20 below illustrates the relationship between age, flexibility training and impact activities and whether the female participants encountered any pain in the lower leg (shin, calf – Achilles, ankle, foot).

Table 20. Lower Leg Pain Yes / No female participants

			Unadjusted			**Adjusted**		
	n	**% pain**	**Odds Ratio (95% CI)**		**p value**	**Odds Ratio (95% CI)**		**p value**
Age								
<30	534	55.6	1.00		<0.001	1.00		0.002
31-40	968	55.5	0.99	(0.80-1.23)		1.05	(0.85-1.28)	
41-50	781	53.6	0.92	(0.74-1.15)		1.02	(0.81-1.31)	
>50	330	41.8	0.58	(0.44-0.76)		0.64	(0.49-0.85)	
Impact								
No	901	43.7	0.56	(0.48-0.66)	<0.001	0.57	(0.48-0.67)	<0.001
Yes	1712	58.2	1.00			1.00		
Flexibility								
No	1312	51.8	0.89	(0.77-1.04)	0.15	0.84	(0.72-0.99)	0.03
Yes	1301	54.7	1.00			1.00		

Adjusted odds ratio: regression analysis including age, impact and flexibility training as covariates

Including age, and regular participation in high impact and flexibility training as covariates in a regression analysis produced the best predictive model for lower leg pain in female participants with a statistically significant contribution from each variable ($p = 0.002$, $p < 0.001$ and $p = 0.03$ respectively).

Table 21 below illustrates the relationship between flexibility training and impact activities and whether the male participants encountered any pain in the lower leg (shin, calf – Achilles, ankle, foot).

Table 21. Lower Leg Pain Yes / No male participants

	n	% pain	Unadjusted			Adjusted		
			Odds Ratio (95% CI)		**p value**	**Odds Ratio (95% CI)**		**p value**
Flexibility Training								
No	367	48.2	0.63	(0.45-0.89)	0.007	0.68	(0.48-0.96)	0.03
Yes	226	59.7	1.00			1.00		
Impact								
No	219	38.4	0.40	(0.28-0.56)	<0.001	0.41	(0.29-0.58)	<0.001
Yes	374	61.0	1.00					

Adjusted Odds Ratio – regression analysis including flexibility and impact training as covariates

Age, training volume, flexibility and impact training were examined to determine their relationship with lower leg pain recorded in the male group. Flexibility and impact training were then included as covariates with regression analysis. The odds of reporting pain in this region increased significantly in male respondents who reported participation in weekly flexibility and high impact training ($p = 0.03$ and $p < 0.001$ respectively).

The relationships of other factors and their contribution to lower leg pain in both females and males can be found in tables in Appendix C.

4.3.7 Intensity of pain / injury

Training volume, core, flexibility, strength and impact training and age were examined for females and males to determine their relationship with intensity of injury.

Table 22 below illustrates the relationship between frequency of BODYBALANCE classes and the intensity of injury where a positive response indicates one or more days of unplanned rest in female participants.

Table 22. Intensity of Injury (requiring at least 1 day of unplanned rest) in female participants

	n	% pain	OR	95% CI	p value
Frequency of BODY BALANCE classes					
0	1680	38.9	1.00		0.04
1 - 2	581	38.0	0.96	(0.79-1.17)	
3 - 4	253	47.8	1.44	(1.10-1.88)	
>5	67	43.3	1.20	(0.73-1.96)	

Only frequency of BODYBALANCE classes was found to have a significant relationship in females ($p = 0.04$). The other variables did not contribute to an improved model.

Table 23 below illustrates the relationship between age, frequency of BODYPUMP classes and strength training and the intensity of injury where a positive response indicates one or more days of unplanned rest in male participants.

Table 23. Intensity of Injury (requiring at least 1 day of unplanned rest) in male participants

			Unadjusted			**Adjusted**		
	n	**% pain**	**Odds Ratio (95% CI)**		**p value**	**Odds Ratio (95% CI)**		**p value**
Age								
<30	190	34.2	1.00		0.008	1.00		0.01
31-40	231	37.2	1.14	(0.76-1.70)		1.15	(0.76-1.73)	
41-50	104	30.8	0.86	(0.51-1.43)		0.88	(0.52-1.48)	
>50	61	13.1	0.29	(0.13-0.65)		0.30	(0.13-0.66)	
BODYPUMP classes per week								
0	168	37.5	1.00		0.01	1.00		0.003
1 - 2	169	35.5	0.92	(0.60-1.43)		0.72	(0.44-1.18)	
3 - 4	203	31.0	0.75	(0.49-1.15)		0.61	(0.38-0.99)	
>5	46	10.9	0.20	(0.08-0.54)		0.16	(0.06-0.43)	
Strength								
No	53	24.5	0.65	(0.34-1.24)	0.19	0.46	(0.22-0.96)	0.04
Yes	533	33.4	1.00			1.00		

Adjusted Odds Ratio – regression analysis including age, frequency of BODYPUMP classes and strength training as covariates

Including age, frequency of BODYPUMP classes and regular participation in strength training as covariates in a regression analysis produced the best predictive model for males reporting a day or more of unplanned rest with a statistically significant contribution from each variable ($p = 0.01$, $p = 0.003$ and $p = 0.04$ respectively).

The relationships of other factors and their contribution to the intensity of recorded pain in both females and males can be found in tables in Appendix C.

Chapter 5 Discussion

5.1 Introduction

This chapter will review the key points of this study and how they compare to previously published papers on injury incidence in the group fitness instructor population. A description of the subjects, contributing factors to recorded pain and limitations of this study will be reviewed. Conclusions regarding significant contributors to injury will be drawn and recommendations for injury prevention for this cohort will be highlighted along with suggestions for further research.

5.2 Subjects

Data obtained from the Les Mills International head office indicates that this sample is representative of the global Les Mills group fitness instructor database despite the low response from only 3 regions. The Les Mills database confirms that approximately 80% of instructors are female with an average age of 38 years. In this sample of 3,208 instructors 2,614 or 81.5% were female and the majority (37.5%) were in the 31 to 40 year age range. Due to the disparity in gender, all analysis was performed separately and therefore discussion of the findings between male and female groups will be independent.

The training volume of the group was high with 83.7% of instructors completing more than six hours of planned exercise per week. A significant number (31.2%) recorded performing more than 11 hours of exercise on a weekly basis. It is estimated that 4% of instructors go on to elite level (6% in the current study) and the global average for duration of teaching classes is 4.8 years. This study had an even mix across years of teaching experience with the majority teaching for more than three years.

5.3 Contributing Factors to Injury

This section will review the factors contributing to injury in each region investigated in the survey.

5.3.1 Age

The majority of participants in this study (37.5%) were in the 31 to 40 year age range, with 39.8% of participants being over the age of 41. The physical demands of teaching group fitness are significant, therefore, the influence of age on the ability to withstand these demands and avoid injury are of particular interest in a cohort of this age range. Despite the fact that a significant positive relationship ($p<0.05$) was observed with the recording of knee pain in females when age and impact were included as covariates (Table 18), it appears that age alone was not a significant factor in the prediction of recorded pain in the female group. This is similar to the findings of studies looking at the incidence of injuries in runners (Jacobs &

Berson, 1986; Taunton et al., 2002) which found that age alone was not a significant predictor of injury. However, those females in the older age groups in this cohort, who regularly participated in high impact training were more at risk for sustaining a knee injury which should be taken into consideration in terms of injury prevention.

A significant negative relationship between age and lower leg pain in females ($p<0.001$) and the intensity of injury (determined by the period of unplanned rest required for recovery) in males ($p<0.008$) was observed (Table 20 & Table 23). This is consistent with the findings of Rothenberger et al. (1988) who found that younger aerobic dance participants (aged less than 40 years) recorded more injuries than older subjects. This might imply that experience in teaching group fitness classes can provide a protective element to sustaining injuries. Knapik et al. (1993) reported that the incidence of injuries in male solders assigned to an infantry battalion declined with age. Similarly Keogh, Hume and Pearson (2006) noted that the lack of increased injuries recorded in older age groups in power lifters may have been due to the increased experience in the older lifters.

It appears that age alone was not associated with an increase in the reporting of pain as may have been expected in this group. In fact, increasing age was observed to have a protective effect in some areas (lower leg pain in females and injury intensity in males). Therefore, there is a possibility that less experienced instructors could look to their older colleagues for guidance on how to construct a weekly training and teaching schedule that minimised the potential for injury. Further to this, Les Mills international can utilise these findings when recruiting new instructors. There is currently a focus on finding younger instructors as the current population is aging, creating sustainability issues. Including injury prevention advice as part of the onboarding process will ensure novice, younger instructors are aware of the risks of injury as identified by this survey.

The inclusion of impact training proved troublesome for the onset of knee pain in the older female participants. This is particularly relevant in this group considering the age of the majority of participants in this cohort which is representative of the global average of instructors. Encouraging the inclusion of non-impact training modalities in older female instructors will potentially help reduce the onset of these symptoms.

5.3.2 Gender

Significant associations were observed between gender and the reporting of any pain, spinal pain, hip pain and whether or not instructors needed at least one day of unplanned rest due to injury. In each of these regions, females recorded a significantly higher prevalence than males.

Although a retrospective injury survey of adults enrolled in the Aerobics Center Longitudinal Study in Texas by Hootman et al. (2001) found no significant differences in the rate or location of injuries between gender; Taunton et al. (2002) observed differences in the anatomical site of injuries in adults attending a Sports Medicine Centre. Specifically, females were observed to have a higher rate of patellofemoral pain syndrome, iliotibial band friction syndrome, along with injuries to gluteus medius and the sacroiliac joint.

The gender differences in this group, suggest that female instructors are more susceptible to encountering pain overall, with a higher frequency of spinal, and hip pain and are more likely to require time off training and instructing as a result of their symptoms. However, it should be noted that the female respondents in this cohort were older, had been attending Les Mills classes for a longer period of time and were less likely to go to elite instructor level than males. This combination of factors may have contributed to the gender differences in reported pain.

This information provides the foundation for establishing gender specific injury prevention strategies, potentially focusing on biomechanical elements that would predispose spinal injury and hip pain such as reduced core strength and hip stability. A conditioning program focusing on these elements may induce similar improvements as found by Durall et al. (2009) and Beckmann Kline, Krauss, Maher and Qu (2013) who incorporated core conditioning into the training programs of gymnasts and ballet dancers with significant reductions in lower back pain.

As many instructors teach multiple programs, encouraging female instructors to include a programme that improves core strength such as CXWORX, may assist in reducing the incidence of spinal and lumbar symptoms in this cohort. In addition, avoiding an over aggressive approach to flexibility training may also serve to reduce injuries in multiple regions in female instructors. In contrast, strength training was a common contributor to the onset of symptoms in the male group (spinal, lumbar regions and injury intensity). Advice on technique and frequency may have an impact on injury incidence in this group.

5.3.3 Impact forces

The inclusion of regular high impact training had a significant positive relationship with the reporting of lower leg pain (including the shin, calf, ankle and foot) in males ($p<0.001$) and females ($p<0.001$) in this cohort (Table 20 & Table 21). The addition of age and participation in flexibility training as covariates produced the best predictive model in females for the reporting of lower leg pain, while adding flexibility produced the best model in males. Weekly participation in high impact training also had a positive relationship with the reporting of knee pain in female participants (Table 18), the addition of age as a covariate produced the best predictive model for pain in this region as discussed above.

Previous studies have explored ground reactions forces while performing common movement patterns experienced by group fitness instructors. Rousanoglou and Boudolos (2005) reported significant differences between high and low impact aerobic dance moves with females experiencing higher vertical ground reaction forces relative to body weight than males. In addition, Hsieh et al. (2009) and Ricard and Veatch (1990) observed similar differences in high versus low impact exercises commonly seen in group fitness classes.

It could be expected that these high impact forces can increase the stress on tissues of the lower leg (including the ankle and foot). As a result this region has been described as the most common site of injury in many studies in group fitness participants and instructors ((Du Toit & Smith, 2001; Francis et al., 1985; Garrick et al., 1986; Mutoh et al., 1988; Requa et al., 1993; Richie et al., 1985; Rothenberger et al., 1988; Vetter et al., 1985). In a review of the epidemiology of aerobic injuries, Garnham et al. (2001) observed that shin injuries accounted for between 16.8% and 40.5% of all injuries and was particularly prominent in the early years of dance aerobic classes possibly due to inappropriate footwear and a lack of variety of formats. The knee has also been described as the most common site of injury when acute and chronic injuries were combined in a study on dance aerobic instructors (Malliou et al., 2013a).

The results of this study reinforce the risks of regular high impact training with respect to the knee and lower leg and suggest that Les Mills group fitness instructors would benefit from monitoring the frequency of classes of this nature included in their weekly routine. With the recent introduction of more variety in group fitness classes, there are options to select other formats which would potentially reduce the exposure to injuries of the knee and lower leg. Educating instructors on footwear choice and maintenance may also reduce the potential for impact related injuries. Although training surfaces, class variety and footwear have improved since earlier studies conducted in the 1980’s, this data indicates that high impact group fitness classes still have a significant bearing on injury incidence in the instructor cohort.

5.3.4 Core Training

In this investigation the inclusion of regular core training had a significant relationship ($p<0.05$) with the reporting of spinal and lumbar pain in females. Specifically, those females who reported attending regular core workouts had reduced odds of reporting pain in these regions (Table 12 & Table 14).

McGill (2010) states that the primary role of the core musculature is to prevent unwanted movement in the torso and therefore a well-trained core is necessary for injury prevention. In addition, Kibler, Press and Sciasca (2006) suggest that core stability allows optimal production and control of force in integrated athletic activity.

Despite these findings, evidence that improving core strength reduces the incidence of back pain in athletic communities is mixed. Nadler et al. (2002) investigated the effect of a core strengthening program on the incidence of lower back pain in NCAA Division 1 collegiate athletes and found no significant change. Other investigations (Cissick, 2011; Davenport, Air, Grierson, & Krabak, 2016; Stuber, Bruno, Sajko & Hayden, 2014) report similar findings. These findings are, however, by no means conclusive. In a review of papers investigating the effects of core stability on athletic populations, Stuber et al. (2014) notes that the studies accepted for review were of low quantity and quality and were conducted on heterogeneous populations preventing the formulation of strong conclusions. For example, Nadler et al. (2002) did see an improvement in the reporting of lower back pain in a group of males after commencing a core strengthening strategy, however, the low number of participants meant these changes were not statistically significant.

In contrast to these studies there is evidence that the effects of core conditioning is effective in some female populations. Durall and Manske (2009) found that a 10 week preseason core conditioning program was effective at reducing the incidence of lower back pain in a group of collegiate women gymnasts. Similarly, Beckmann Kline et al. (2013) observed a reduction in low back pain in ballet dancers who undertook six weeks of core training. The data in the current study also suggests a significant positive relationship with core training and reduced recording of spinal and lower back symptoms in the female members of this cohort, potentially reinforcing the existence of a gender specific training benefit. This relationship has also been observed with regards to knee pain in a study by Zazulak, Hewett, Reeves, Goldberg, and Cholewicki (2007). This study found that decreased neuro muscular control of the trunk (core instability) increased the likelihood of knee ligament injuries in females but not males.

Males in this study reported an increased incidence of knee pain in those who undertook regular core workouts. This is in conflict of a number of studies (Hides & Stanton, 2014; Leetun, Ireland, Willson, Ballantyne, & Davis, 2004; Perrott, Pizzari, & Cook, 2013) which demonstrate significant benefits gained from improving core strength in the prevention of lower limb injuries. Due to the retrospective nature of this investigation, a cause and effect relationship of core training and knee pain in males cannot be established. The possibility that males with previous knee pain undertook core training in an attempt to manage these symptoms cannot be accounted for.

The data from this investigation is aligned with previous studies that suggest that increasing core strength may have benefit in the reduction of lower back pain in the female dance and gymnastic population (Beckmann Kline et al., 2013; Durall and Manske, 2009). Interestingly, a similar trend was not apparent in males. There is therefore a strong indication that maintaining core strength is of particular importance with regards to injury prevention in female group fitness instructors.

5.3.5 Training Load

Training load was found to have a significant relationship ($p<0.05$) with the recording of any pain in the female group of this cohort. The odds of recording any pain increased with moderate training loads (6-10 and 11-15 hours per week) and then reduced in the 15 plus hours per week group.

Although it is well accepted that increased training volume results in increased rate of injury (Gabbett & Jenkins, 2011), recent work by Gabbett (2016) has introduced the concept that appropriate training at higher volumes can be protective against injury. For example McNamara, Gabbett, and Naughton (2017) have reported that systematically increasing the chronic training load of cricket bowlers resulted in a decrease in the likelihood of injury.

The reduction of recorded injuries in the highest training volume group in the female cohort of this investigation (15 plus hours) may reflect an inverted U relationship previously described in the literature on training load and the incidence of injury. For example, in a study on elite soccer players (Arnason et al., 2004), those who had a moderate rate of match and training exposures had more injuries than those in the low and high frequencies. This finding may indicate that a low or high training load in group fitness instructors can be protective against the onset of pain, with the majority of risk lying in the groups with a moderate exposure. Fifty three percent of the instructors who responded to the survey reported training six to 10 hours per week, while a further 21 percent trained between 11 to 15 hours per week. With such a large proportion lying in the at-risk range, carefully managing acute versus chronic training loads in this group may result in reducing injury. There is a possibility that instructors in the moderate training load category are available to take on cover classes in addition to their weekly scheduled workouts. This could significantly affect their acute to chronic training load, predisposing them to injury. Providing education on the risks associated with these acute spikes in training load will help instructors plan and manage their training schedules more effectively.

The fact that training load did not feature more prominently as a contributor to regional symptoms or intensity of injury is of interest. This may be due to the fact that despite having a relatively high volume, group fitness instructors tend to teach a variety of classes. Comparative groups with similar training volumes will often have a specific training goal which may result in a more specialised approach to training, resulting in less variety. Encouraging this varied approach to teaching different class formats and along with monitoring other conditioning sessions will help to manage the high training loads observed in this group.

5.3.6 Flexibility Training

In the female group, the likelihood of recording pain increased with regular flexibility training in the spinal region, lumbar spine, hip and lower leg. In the spinal and lumbar region, a lack of regular core training was a covariate for the best predictive model (Table 12 & Table 14), while in the lower leg, flexibility training was only a significant factor when combined with age and regular impact training as covariates.

In males, regular flexibility training was positively correlated to the recording of spinal pain and included in the best predictive model for pain in this region when coupled with strength training as a covariate. Flexibility training was also positively associated with reported hip pain in this group. Regular attendance in bodybalance classes was identified as a covariate for the best predictive model for hip pain, while high impact training was combined with flexibility training in the best predictive model for predicting lower leg pain.

The findings from this cohort would seem to suggest that flexibility training on a regular basis increases the likelihood of experiencing pain particularly in spinal regions, the hip, and lower leg in both males and females. However, a number of studies (Cramer et al., 2015; Holton & Barry, 2014; Penman et al., 2012) have demonstrated a low prevalence of injury in yoga practitioners and instructors, which is relevant in this group as many of the respondents in this study undertook regular yoga classes to achieve the flexibility training component of their weekly routine.

In addition, a study by Malliou et al., (2007) was the only one found to investigate the effect of a stretching program on the injury rate of dance aerobic instructors. They found that including different types of stretches while warming up and cooling down did not have a significant effect on the injury rates of the participants over a 2 year period.

Further, despite the fact that a number of studies have questioned the efficacy of regular stretching in the prevention of injury (Behm, Blazevich, Kay, & McHugh, 2016; Brushoj et al., 2008; Stojanovic & Ostojic, 2011; Witvrouw, Mahieu, Danneels & McNair, 2004; Yeung & Yeung, 2001) it is unlikely that a cause and effect relationship of the recording of pain in the above regions and regular flexibility training can be claimed. It is possible that these participants adopted a regular flexibility regime in an attempt to address pre-existing pain or current injuries experienced at the time of the survey. Due to the retrospective nature of the data collection neither the cause and effect relationship nor the adoption of flexibility training due to existing pain can be verified.

5.3.7 Strength Training

The results of this study show that regularly undertaking strength workouts had a significant relationship with reported spinal and lumbar pain in males ($p<0.05$) (Table 13 & Table 15).

Those who completed regular weekly strength training sessions had an increased likelihood of encountering pain in these regions. The combination of regular strength and flexibility training provided the best predictive model for the reporting of spinal pain in this group. Regular strength training was also a covariate along with age and weekly bodypump classes in the best predictive model for predicting whether or not males would need at least one day off through injury. Interestingly, a higher frequency of weekly bodypump classes (a light weight high repetition weight training class) lowered the odds of needing time off through injury.

Lubetzky-Vilnai et al. (2009) found a significantly higher frequency of weight training injuries in males in their survey of members of sports centres in Israel. In terms of location of injuries from weight training, Keogh and Winwood (2017) and Aasa, Svartholm, Andersson, and Berglund (2017) found that lower back injuries were included among the more common injury locations across a variety of weight training disciplines. Siewe et al. (2014) found that squatting was the most common cause of injury in bodybuilders with the lower back the most common site of injury. The authors also noted that a large proportion of bodybuilders in their sample reported pain that did not interrupt their training. This is in contrast to this group who reported that regular strength training significantly increased the likelihood of needing at least one day of unplanned rest due to injury.

It would appear from these findings that the inclusion of regular strength training results in an increased element of risk of pain and injury in spinal regions in male group fitness instructors as found in previous studies. It is also evident that these workouts can result in an interruption in training and teaching particularly in younger males. The fact that regular bodypump classes reduced the risk of needing time off through injury in this group, may suggest that a high repetition, low weight, training approach may provide less risk. This information provides a useful component to injury prevention strategies for male group fitness instructors. In addition, healthcare providers can use this information when assessing and treating male group fitness instructors. Paying particular attention to the strength training component of those suffering from spinal or lower back pain, may shed light on a key contributing factor when planning rehabilitation.

Chapter 6 Limitations

The primary limitation of this study is that the survey was not specifically designed to investigate relationships between injuries and training methods in this group. As a result, the structure some of the variables had to be reduced to binary values as opposed to using an ordinal scale which may have shed further light on these relationships. For example, injury severity was recorded as, never, occasionally, daily or currently which was not able to deliver an accurate sense of degree of injury. This lack of specific design may have resulted in an alteration in the reporting in some areas due to lack of a more detailed scale. Similarly, there was a limitation to the type of statistical analysis that was undertaken as variables (such as age and training load) were recorded in ordinal categories rather than continuous variables.

Retrospective injury surveys rely on an accurate recall of details across the duration of the time period under investigation (in this case 6 months). Failure to remember injury details can influence the outcomes of the investigation. Instructors were also required to record training factors such as volume and the types of modalities undertaken on a weekly basis. These factors can vary significantly over a 6 month period which may again have an effect on recall.

The low response rate may restrict the ability to apply the findings of this investigation to the broader instructor population. In addition, the low numbers of males in this survey prevented the comparison of injury rates with regards to gender.

Finally, training variables were also combined which may prevent an accurate assessment of the impact of specific training modalities. For example regular attendance of bodypump (a high repetition, low weight resistance training class) was coupled with a positive response to training with a strength focus and weight training. Similarly flexibility training included regular bodybalance (a yoga, Pilates fusion class) and yoga attendance.

Chapter 7 Future Directions

The results of this survey have generated useful information to design a follow up study in this instructor group. To ensure greater accuracy of injury information, a prospective survey could be conducted. Secondly, targeting one group in particular, such as trainers from the UK, may help create the opportunity for closer monitoring and regular communication and therefore improve response rates.

Providing a continuous scale for the collection of data for variables such as injury severity, age and training volumes will also enable a greater variety of statistical analysis. Specific training variables can also be separated to improve the ability to determine the impact of each training modality.

Following the completion of a well-structured prospective survey, an intervention could be undertaken to determine its effect on injury prevention. For example, introducing regular core conditioning to a group of female instructors who are not currently using this modality in their training protocol, may provide useful insight to the findings from this cohort.

Chapter 8 Conclusions

This study's purpose was to undertake a retrospective analysis of a survey to investigate the effects of age and training history on the incidence of spinal and lower limb pain in Les Mills group fitness instructors These findings highlight risks and benefits of teaching and participating in group fitness classes and adopting various training practises in this group. These factors should be taken into consideration when instructors organise their weekly teaching and training schedules.

For example, the influence of different training modalities had varying effects according to gender. The adoption of regular core conditioning may have a protective influence on pain in spinal regions in female instructors. Conversely, flexibility training was associated with a higher rate of recording of pain in this group. In males, weekly strength training was associated with an increased likelihood of encountering spinal pain and an increase in the intensity of injuries.

There were also indications that older instructors may have established weekly protocols that minimise the onset of injury. For example, females in older age groups experienced less recorded pain overall while older males had a reduction in intensity of injuries.

Regular high impact training had a significant positive relationship with the recording of knee and lower leg pain in both males and females. With the variety of classes available it would appear that including a mix of high and low or non-impact classes would serve to reduce the incidence of lower limb pain.

Training load also had an interesting effect in the female group. Those who had a moderate training volume were at higher risk of recording any pain than those in the low and high recorded volumes. This observation may highlight that instructors who have a moderate load are at higher risk, perhaps because they are more likely to cover non-scheduled classes and therefore experience greater fluctuations in acute training load.

Educating instructors on these factors may serve to reduce injury and increase longevity in the global Les Mills group fitness instructor population. In addition, this information will provide useful guidance for health practitioners who are managing the rehabilitation of group fitness instructors. Future studies can focus on establishing cause and effect of the observations in this cohort.

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Appendices

Appendix A: Consent

You are invited to participate in a web-based online survey on injury incidence. This is a research project conducted by Les Mills International. It should take approximately 15-20 minutes to complete.

Your participation in this survey is voluntary. You may refuse to take part in the research by exiting the survey at any time. You will receive no direct benefits from participating in this survey. However, your responses may help us learn more about injury incidence that could lead to future manuscript publications, conference presentations, and/or education sessions with statistics about injury risks and potential suggestions to reduce the risks.

Your survey answers will be sent to Qualtrics where your name and email address are not stored. No identifying information will be included in any publications, presentations or education based on these data. Completing the survey will be confirmation that you consent to the use of your answers.

Appendix B: Survey Questions:

Survey Questions

Overuse Injuries 2

Q1 What is your age?

- 16-20 (1)
- 21-25 (2)
- 26-30 (3)
- 31-35 (4)
- 36-40 (5)
- 41-45 (6)
- 46-50 (7)
- 51-55 (8)
- 56-60 (9)
- 61-65 (10)
- 66-70 (11)

Q2 What do you identify as your gender?

- Male (1)
- Female (2)
- Prefer not to disclose (3)

Q3 Are you a Les Mills trainer or instructor?

- Trainer (1)
- Instructor (2)

Q4 Who is your Les Mills local partner?

- New Zealand (30)
- US _ Mid Atlantic (1)
- US _ Midwest (5)
- US _ North East (2)
- US _ South Central (6)
- US _ South East (3)
- US _ West Coast (4)
- Asia Pacific (18)
- Brazil (24)
- Chile (19)
- China (23)
- Columbia (25)
- Denmark (11)
- Ecuador (20)
- Estonia (17)
- Finland (10)
- France (8)
- Germany (13)
- Israel (22)
- Italy (14)
- Mexico (26)
- Netherlands (9)
- Norway (16)
- Panama (21)
- Peru (27)
- Poland (12)
- Sweden (15)
- United Kingdom (7)
- Other (28)
- Unsure (29)

Q5 Which Les Mills classes did you instruct, coach or attend regularly (once weekly or more) in the past year? Select all that apply.

- ❑ BODYBALANCE/BODYFLOW (1)
- ❑ BODYATTACK (2)
- ❑ BODYCOMBAT (3)
- ❑ BODYJAM (4)
- ❑ BODYSTEP (5)
- ❑ RPM (6)
- ❑ SH'BAM (7)
- ❑ BODYVIVE (8)
- ❑ CXWORX (9)
- ❑ BODYPUMP (10)
- ❑ GRIT series (11)

Q6 How many years have you been an instructor, coach or participant in Les Mills classes?

- ❍ 0-2 (1)
- ❍ 3-5 (2)
- ❍ 6-9 (3)
- ❍ 10+ (4)

Q7 Which of the following activities did you complete regularly in the past year for at least 1-2 hours per week? Select all that apply.

- ❑ Yoga (ashtanga, bikram, hatha, iyengar, vinyasa) (2)
- ❑ Endurance Exercise (running, cycling, swimming, hiking, rowing) (3)
- ❑ Mixed Martial Arts (aikido, judo, karate, kung fu, muay thai) (4)
- ❑ Club or Team Sports (soccer, basketball, volleyball, lacrosse) (5)
- ❑ Recreational or Individual Sports (tennis, golf, skiing, surfing) (6)
- ❑ Dance (ballroom, jazz, hip hop) (9)
- ❑ Weights (Bodybuilding, Power Lifting, Circuit Training) (8)
- ❑ High Intensity Interval Training (CrossFit, Insanity, Tabata) (7)
- ❑ OTHER with Flexibility Focus (10)
- ❑ OTHER with Cardiovascular or Aerobic Focus (1)
- ❑ OTHER with Strength Training Focus (11)
- ❑ NONE of the above, I only participate in Les Mills classes or small team training (12)

Q8 How many TOTAL hours of planned exercise do you typically complete in a single week?

- 1-5 (1)
- 6-10 (2)
- 11-15 (3)
- more than 15 (4)

Q9 Do you instruct or attend BODYBALANCE/BODYFLOW classes on a weekly basis?

- YES (1)
- NO (2)

If NO Is Selected, Then Skip To In your time as an instructor, have y...

Q10 How many BODYBALANCE/BODYFLOW classes do you typically instruct or attend in a single week?

- 1-2 (1)
- 3-4 (2)
- 5+ (3)

Q11 Do you instruct or attend BODYATTACK classes on a weekly basis?

- YES (1)
- NO (2)

If NO Is Selected, Then Skip To Do you instruct or complete BODYCOMBA...

Q12 How many BODYATTACK classes do you typically instruct or attend in a single week?

- 1-2 (1)
- 3-4 (2)
- 5+ (3)

Q13 Do you instruct or attend BODYCOMBAT classes on a weekly basis?

- ❍ YES (1)
- ❍ NO (2)

If NO Is Selected, Then Skip To Do you instruct or complete BODYJAM c...

Q14 How many BODYCOMBAT classes do you typically instruct or attend in a single week?

- ❍ 1-2 (1)
- ❍ 3-4 (2)
- ❍ 5+ (3)

Q15 Do you instruct or attend BODYJAM classes on a weekly basis?

- ❍ YES (1)
- ❍ NO (2)

If NO Is Selected, Then Skip To Do you instruct or complete BODYSTEP ...

Q16 How many BODYJAM classes do you typically instruct or attend in a single week?

- ❍ 1-2 (1)
- ❍ 3-4 (2)
- ❍ 5+ (3)

Q17 Do you instruct or attend BODYSTEP classes on a weekly basis?

- ❍ YES (1)
- ❍ NO (2)

If NO Is Selected, Then Skip To Do you instruct or complete RPM class...

Q18 How many BODYSTEP classes do you typically instruct or attend in a single week?

- ❍ 1-2 (1)
- ❍ 3-4 (2)
- ❍ 5+ (3)

Q19 Do you instruct or attend RPM classes on a weekly basis?

- ❍ YES (1)
- ❍ NO (2)

If NO Is Selected, Then Skip To Do you instruct or complete SH'BAM cl...

Q20 How many RPM classes do you typically instruct or attend in a single week?

- ❍ 1-2 (1)
- ❍ 3-4 (2)
- ❍ 5+ (3)

Q21 Do you instruct or attend SH'BAM classes on a weekly basis?

- ❍ YES (1)
- ❍ NO (2)

If NO Is Selected, Then Skip To Do you instruct or complete BODYVIVE ...

Q22 How many SH'BAM classes do you typically instruct or attend in a single week?

- ❍ 1-2 (1)
- ❍ 3-4 (2)
- ❍ 5+ (3)

Q23 Do you instruct or attend BODYVIVE classes on a weekly basis?

- ❍ YES (1)
- ❍ NO (2)

If NO Is Selected, Then Skip To Do you instruct or complete CXWORX cl...

Q24 How many BODYVIVE classes do you typically instruct or attend in a single week?

- ❍ 1-2 (1)
- ❍ 3-4 (2)
- ❍ 5+ (3)

Q25 Do you instruct or attend CXWORX classes on a weekly basis?

- YES (1)
- NO (2)

If NO Is Selected, Then Skip To Do you instruct or complete BODYPUMP ...

Q26 How many CXWORX classes do you typically instruct or attend in a single week?

- 1-2 (1)
- 3-4 (2)
- 5+ (3)

Q27 Do you instruct or attend BODYPUMP classes on a weekly basis?

- YES (1)
- NO (2)

If NO Is Selected, Then Skip To Do you participate in GRIT series tra...

Q28 How many BODYPUMP classes do you typically instruct or attend in a single week?

- 1-2 (1)
- 3-4 (2)
- 5+ (3)

Q29 Do you participate in GRIT series training sessions on a weekly basis? (NOT including GRIT series coaching)

- YES (1)
- NO (2)

If NO Is Selected, Then Skip To In the last 6 months, have you experi...

Q30 How many GRIT series training sessions do you typically complete (NOT coach) in a single week?

- 1-2 (1)
- 3-4 (2)
- 5+ (3)

Q32 In the last 6 months, have you experienced severe headache pain or a migraine headache? Your symptoms may include extreme pain on one or both sides of your head, visual disturbances, speech problems, tingling sensations in your arms or legs, nausea, or vomiting.

- ❍ Never (1)
- ❍ Occasionally (2)
- ❍ Daily (3)
- ❍ Currently (4)

If Never Is Selected, Then Skip To In the past 6 months, have you experi...

Q33 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any headache pain during these sessions, please click the >> button.)

Q34 In the last 6 months, have you experienced pain or stiffness anywhere in your neck (from the bottom of your head to the top of your shoulders)? Your symptoms may include a decreased range of motion as you move your head side to side.

- ❍ Never (1)
- ❍ Occasionally (2)
- ❍ Daily (3)
- ❍ Currently (4)

If Never Is Selected, Then Skip To In your time as an instructor, have y...

Q35 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any neck pain during these sessions, please click the >> button.)

Q36 In the last 6 months, have you experienced pain or stiffness anywhere around your upper back (from the base of your neck to the area between your shoulder blades)? Your symptoms may include difficulty moving your head or shoulder blades as well as irritation as you twist your trunk from side to side.

- ❍ Never (1)
- ❍ Occasionally (2)
- ❍ Daily (3)
- ❍ Currently (4)

If Never Is Selected, Then Skip To In your time as an instructor, have y...

Q37 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any upper back pain during these sessions, please click the >> button.)

Q38 In the last 6 months, have you experienced pain or stiffness anywhere around the front or side of your shoulder? Your symptoms may include problems sleeping, irritation as you lift your arm, or difficulty reaching behind your back.

- ❍ Never (1)
- ❍ Occasionally (2)
- ❍ Daily (3)
- ❍ Currently (4)

If Never Is Selected, Then Skip To In the last 6 months, have you experi...

Q39 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any shoulder pain during these sessions, please click the >> button.)

Q40 In the last 6 months, have you experienced pain around your elbow, this may be accompanied by weakness in your forearm. Your pain may be exacerbated by squeezing or gripping objects such as weights or bicycle handle bars.

- Never (1)
- Occasionally (2)
- Daily (3)
- Currently (4)

If Never Is Selected, Then Skip To In your time as an instructor, have y...

Q41 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any elbow pain during these sessions, please click the >> button.)

Q42 In the last 6 months, have you experienced pain or a deep ache in your wrist, this may be accompanied by numbness in your fingers. Your pain may be exacerbated by squeezing or gripping objects such as weights or bicycle handle bars.

- Never (1)
- Occasionally (2)
- Daily (3)
- Currently (4)

If Never Is Selected, Then Skip To In your time as an instructor, have y...

Q43 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any wrist pain during these sessions, please click the >> button.)

Q44 In the last 6 months, have you experienced pain or stiffness in your middle or lower back? Your symptoms may include sharp, localized pain after lifting heavy objects or high intensity exercise.

- ❍ Never (1)
- ❍ Occasionally (2)
- ❍ Daily (3)
- ❍ Currently (4)

If Never Is Selected, Then Skip To In your time as an instructor, have y...

Q45 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any back pain during these sessions, please click the >> button.)

Q46 In the last 6 months, have you experienced pain or tenderness in or around your hip or inner thigh? Your symptoms may include sharp, localized pain when you bring your legs together or when you raise your knee.

- ❍ Never (1)
- ❍ Occasionally (2)
- ❍ Daily (3)
- ❍ Currently (4)

If Never Is Selected, Then Skip To In your time as an instructor, have y...

Q47 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any hip pain during these sessions, please click the >> button.)

Q48 In the last 6 months, have you experienced pain or stiffness in or around your hip or outer thigh? Your symptoms may include sharp, localized pain during exercise particularly running and cycling motions.

- ❍ Never (1)
- ❍ Occasionally (2)
- ❍ Daily (3)
- ❍ Currently (4)

If Never Is Selected, Then Skip To In the last 6 months, have you experi...

Q49 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any hip pain during these sessions, please click the >> button.)

Q50 In the last 6 months, have you experienced pain in the muscles in the front or back of your thigh? Your symptoms may include sharp, localized pain during exercise particularly running or cycling motions in addition to tenderness and bruising.

- ❍ Never (1)
- ❍ Occasionally (2)
- ❍ Daily (3)
- ❍ Currently (4)

If Never Is Selected, Then Skip To In the last 6 months, have you experi...

Q51 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any thigh pain during these sessions, please click the >> button.)

Q52 In the last 6 months, have you experienced pain or stiffness in or around the outside of your knee? Your pain may be exacerbated by lateral movements, squats or running.

- ❍ Never (1)
- ❍ Occasionally (2)
- ❍ Daily (3)
- ❍ Currently (4)

If Never Is Selected, Then Skip To In your time as an instructor, have y...

Q53 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any knee pain during these sessions, please click the >> button.)

Q54 In the last 6 months, have you experienced pain at the front of the knee or below the kneecap? Your symptoms may include stiffness or soreness after prolonged sitting, squats, or stair climbing.

- ❍ Never (1)
- ❍ Occasionally (2)
- ❍ Daily (3)
- ❍ Currently (4)

If Never Is Selected, Then Skip To In the past 6 months, have you experi...

Q55 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any knee pain during these sessions, please click the >> button.)

Q56 In the last 6 months, have you experienced pain along the length of your shin? This pain may be exacerbated by exercising on hard surfaces, high impact cardio classes, or pointing your toes.

- Never (1)
- Occasionally (2)
- Daily (3)
- Currently (4)

If Never Is Selected, Then Skip To In the last 6 months, have you experi...

Q57 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any shin pain during these sessions, please click the >> button.)

Q58 In the last 6 months, have you experienced pain or stiffness around your ankle? Your symptoms may include swelling, bruising, or an inability to bear weight.

- Never (1)
- Occasionally (2)
- Daily (3)
- Currently (4)

If Never Is Selected, Then Skip To In the last 6 months, have you experi...

Q59 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any ankle pain during these sessions, please click the >> button.)

Q60 In the last 6 months, have you experienced pain from the back of your lower leg to the back of your heel that may be exacerbated by standing on your toes or by impact during cardio classes? Your symptoms may also include tenderness, swelling, or stiffness.

- Never (1)
- Occasionally (2)
- Daily (3)
- Currently (4)

If Never Is Selected, Then Skip To In your time as an instructor, have y...

Q61 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any lower leg or heel pain during these sessions, please click the >> button.)

Q62 In the last 6 months, have you experienced pain on the bottom of your foot and heel? Your symptoms may include extreme stiffness upon waking or during high impact cardio classes.

- Never (1)
- Occasionally (2)
- Daily (3)
- Currently (4)

If Never Is Selected, Then Skip To In general, define the timing of the ...

Q63 During which activities were you instructing or participating when the pain was most severe? Select all that apply. (If you do not feel any heel pain during these sessions, please click the >> button.)

Q64 In general, define the timing of the injuries (pain or stiffness related to fractures, muscle tears, sprains, strains, ruptures, severe bruises) you reported in the previous questions.

- ❍ Chronic injury (present for longer than 6 months) prior to my experience with Les Mills classes (1)
- ❍ Chronic injury (present for longer than 6 months) since I have been instructing or completing Les Mills classes (2)
- ❍ Acute injury (singular, isolated event of sudden onset that occurred in the last 6 months) (3)
- ❍ None of the above, I have not experienced any pain before, during or after exercise in the last 6 months (4)

Q65 In general, define the intensity of the injuries (pain or stiffness related to fractures, muscle tears, sprains, strains, ruptures, severe bruises) you reported in the previous questions.

- ❍ Mild. No change in training routine. No classes required a substitute instructor or a participation absence. (1)
- ❍ Moderate. At least 1 day of unplanned rest. An occasional class required a substitute instructor or a participation absence. (2)
- ❍ Severe. Over 1 week of unplanned rest. Required a physician visit as well as a scan and treatment plan. (3)
- ❍ None of the above, I have not experienced any pain before, during or after exercise in the last 6 months (4)

Appendix C: Data Tables

Data table 1 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and whether female participants encountered any pain.

Data table 1. Any pain (Yes / No) - Females

	n	% pain	OR	95% CI	p value
Age					
<30	534	96.4	1.00		0.79
31-40	969	95.8	0.84	(0.48 – 1.45)	
41-50	781	96.2	0.92	(0.51 – 1.66)	
>50	330	95.2	0.72	(0.37 – 1.43)	
Training Volume - Hrs / Week					
1 – 5	417	95.4	1.00		0.01
6 - 10	1394	96.6	1.37	(0.79 – 2.36)	
11 - 15	550	96.4	1.27	(0.67 – 2.40)	
>15	253	92.1	0.56	(0.29 – 1.06)	
Core Training					
No	1543	95.7	0.87	(0.58 – 1.30)	0.49
Yes	1071	96.3	1.00		
Flexibility Training					
No	1313	95.7	0.86	(0.58 – 1.27)	0.46
Yes	1301	96.2	1.00		
Strength Training					
No	265	95.8	0.97	(0.51 – 1.84)	0.93
Yes	2349	96.0	1.00		
Impact					
No	902	95.5	0.83	(0.56 – 1.24)	0.36
Yes	1712	96.2	1.00		

Data table 2 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and whether the male participants encountered any pain.

Data table 2. Any Pain (Yes / No) - Males

	n	% pain	OR	95% CI	p value
Age					
<30	192	94.3	1.00		0.38
31-40	235	91.5	0.65	(0.31 – 1.40)	
41-50	106	96.2	1.55	(0.48 – 4.99)	
>50	61	91.8	0.68	(0.23 – 2.04)	
Training Volume - Hrs / Week					
1 – 5	108	93.5	1.00		0.87
6 - 10	290	93.8	1.05	(0.43 – 2.58)	
11 - 15	132	91.7	0.76	(0.29 – 2.04)	
>15	64	93.8	1.04	(0.29 – 3.70)	
Core Training					
No	393	92.4	0.63	(0.30 – 1.32)	0.23
Yes	201	95.0	1.00		
Flexibility Training					
No	367	91.8	0.52	(0.25 – 1.08)	0.08
Yes	227	95.6	1.00		
Strength Training					
No	54	87.0	0.44	(0.18 – 1.04)	0.06
Yes	540	93.9	1.00		
Impact					
No	219	93.2	0.97	(0.50 – 1.89)	0.93
Yes	375	93.3	1.00		

Data table 3 illustrates the relationship between core and flexibility training and whether female participants encountered any pain in the neck, thoracic or lumbar regions of the spine.

Data table 3. Spinal Pain Yes / No - Females

	n	% pain	OR	95% CI	p value
Age					
<30	534	83.1	1.00		0.75
31-40	969	84.6	1.12	(0.84 – 1.49)	
41-50	781	83.2	1.01	(0.75 – 1.35)	
>50	330	82.4	0.95	(0.66 – 1.37)	
Training Volume - Hrs / Week					
1 – 5	417	83.5	1.00		0.21
6 - 10	1394	84.8	1.11	(0.82 – 1.49)	
11 - 15	550	82.5	0.94	(0.67 – 1.32)	
>15	253	79.8	0.79	(0.53 – 1.17)	
Core Training					
No	1543	85.0	1.27	(1.03 – 1.56)	0.03
Yes	1071	81.7	1.00		
Flexibility Training					
No	1313	81.4	0.72	(0.59 – 0.89)	0.002
Yes	1301	85.9	1.00		
Strength Training					
No	265	84.5	1.08	(0.76 – 1.53)	0.68
Yes	2349	83.5	1.00		
Impact					
No	902	84.5	1.10	(0.88 – 1.37)	0.39
Yes	1712	83.2	1.00		

Data table 4 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and whether the male participants encountered any pain in the neck, thoracic or lumbar regions of the spine.

Data table 4. Spinal Pain Yes / No - Males

	n	% pain	OR	95% CI	p value
Age					
<30	192	80.2	1.00		0.73
31-40	235	78.3	0.90	(0.56 – 1.43)	
41-50	106	82.1	1.13	(0.61 – 2.08)	
>50	61	75.4	0.76	(0.38 – 1.50)	
Training Volume - Hrs / Week					
1 – 5	108	73.1	1.00		0.11
6 - 10	290	83.1	1.81	(1.07 – 3.05)	
11 - 15	132	75.8	1.15	(0.64 – 2.05)	
>15	64	79.7	1.44	(0.69 – 3.03)	
Core Training					
No	393	79.4	1.02	(0.67 – 1.55)	0.94
Yes	201	79.1	1.00		
Flexibility Training					
No	367	76.0	0.58	(0.38 – 0.89)	0.01
Yes	227	84.6	1.00		
Strength Training					
No	54	59.3	0.34	(0.19 – 0.60)	0.000
Yes	540	81.3	1.00		
Impact					
No	219	81.3	1.22	(0.79 – 1.85)	0.36
Yes	375	78.1	1.00		

Data table 5 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and whether the female participants encountered any pain in the lumbar spine.

Data table 5. Lumbar Pain Yes / No - Females

	n	% pain	OR	95% CI	p value
Age					
<30	534	62.9	1.00		0.36
31-40	969	60.2	0.89	(0.72 – 1.11)	
41-50	781	58.8	0.84	(0.67 – 1.05)	
>50	330	57.6	0.80	(0.60 – 1.06)	
Training Volume - Hrs / Week					
1 – 5	417	61.6	1.00		0.63
6 - 10	1394	60.5	0.95	(0.76 – 1.19)	
11 - 15	550	57.8	0.85	(0.66 – 1.11)	
>15	253	59.3	0.91	(0.66 – 1.25)	
Core Training					
No	1543	62.7	1.31	(1.12 – 1.54)	0.001
Yes	1071	56.1	1.00		
Flexibility Training					
No	1313	57.6	0.82	(0.70 – 0.96)	0.01
Yes	1301	62.4	1.00		
Strength Training					
No	265	61.1	1.06	(0.81 – 1.37)	0.69
Yes	2349	59.9	1.00		
Impact					
No	902	60.6	1.04	(0.88 – 1.23)	0.62
Yes	1712	59.6	1.00		

Data table 6 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and whether the male participants encountered any pain in the lumbar spine.

Data table 6. Lumbar Pain Yes / No - Males

	n	% pain	OR	95% CI	p value
Age					
<30	192	61.5	1.00		0.86
31-40	235	58.7	0.89	(0.60 – 1.32)	
41-50	106	60.4	0.96	(0.59 – 1.55)	
>50	61	55.7	0.79	(0.44 – 1.41)	
Training Volume - Hrs / Week					
1 – 5	108	53.7	1.00		0.08
6 - 10	290	63.4	1.50	(0.96 – 2.34)	
11 - 15	132	53.0	0.97	(0.59 – 1.62)	
>15	64	65.6	1.65	(0.87 – 3.12)	
Core Training					
No	393	58.3	0.85	(0.60 – 1.20)	0.36
Yes	201	62.2	1.00		
Flexibility Training					
No	367	57.2	0.77	(0.55 – 1.08)	0.13
Yes	227	63.4	1.00		
Strength Training					
No	54	37.0	0.36	(0.20 – 0.65)	0.001
Yes	540	61.9	1.00		
Impact					
No	219	60.7	1.08	(0.77 – 1.52)	0.67
Yes	375	58.9	1.00		

Data table 7 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and whether the female participants encountered any pain in the hip region.

Data table 7. Hip Pain Yes / No - Females

	n	% pain	OR	95% CI	p value
Age					
<30	534	39.3	1.00		0.87
31-40	969	39.7	1.02	(0.82 – 1.26)	
41-50	781	41.4	1.09	(0.87 – 1.36)	
>50	330	40.0	1.03	(0.78 – 1.36)	
Training Volume - Hrs / Week					
1 – 5	417	38.8	1.00		0.70
6 - 10	1394	40.6	1.08	(0.86 – 1.35)	
11 - 15	550	41.3	1.11	(0.85 – 1.44)	
>15	253	37.5	0.95	(0.69 – 1.31)	
Core Training					
No	1543	40.8	1.07	(0.91 – 1.25)	0.41
Yes	1071	39.2	1.00		
Flexibility Training					
No	1313	37.9	0.83	(0.71 – 0.97)	.019
Yes	1301	42.4	1.00		
Strength Training					
No	265	41.5	1.06	(0.82 – 1.38)	0.64
Yes	2349	40.0	1.00		
Impact					
No	902	41.4	1.08	(0.92 – 1.27)	0.37
Yes	1712	39.5	1.00		

Data table 8 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and whether the male participants encountered any pain in the hip region.

Data table 8. Hip Pain Yes / No - Males

	n	% pain	OR	95% CI	p value
Age					
<30	191	33.5	1.00		0.27
31-40	235	31.9	0.93	(0.62 – 1.40)	
41-50	106	23.6	0.61	(0.36 – 1.05)	
>50	61	26.2	0.71	(0.37 – 1.34)	
Training Volume - Hrs / Week					
1 – 5	108	25.9	1.00		0.03
6 - 10	290	30.0	1.22	(0.74 – 2.02)	
11 - 15	132	27.3	1.07	(0.60 – 1.91)	
>15	63	46.0	2.44	(1.26 – 4.70)	
Core Training					
No	392	30.1	0.97	(0.67 – 1.40)	0.85
Yes	201	30.8	1.00		
Flexibility Training					
No	367	26.7	0.64	(0.45 – 0.91)	0.01
Yes	226	36.3	1.00		
Strength Training					
No	54	25.9	0.79	(0.42 – 1.49)	0.46
Yes	539	30.8	1.00		
Impact					
No	219	29.7	0.95	(0.66 – 1.37)	0.79
Yes	374	30.7	1.00		

Data table 9 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and whether the female participants encountered any pain in the knee region.

Data table 9. Knee Pain Yes / No - Females

	n	% pain	OR	95% CI	p value
Age					
<30	534	57.5	1.00		0.12
31-40	969	55.1	0.91	(0.73 – 1.12)	
41-50	781	60.7	1.14	(0.91 – 1.43)	
>50	330	59.4	1.08	(0.82 – 1.43)	
Training Volume - Hrs / Week					
1 – 5	417	54.9	1.00		0.48
6 - 10	1394	58.3	1.15	(0.92 – 1.43)	
11 - 15	550	59.5	1.20	(0.93 – 1.56)	
>15	253	56.1	1.05	(0.77 – 1.44)	
Core Training					
No	1543	57.9	1.01	(0.87 – 1.19)	0.87
Yes	1071	57.6	1.00		
Flexibility Training					
No	1313	58.6	1.07	(0.91 – 1.24)	0.43
Yes	1301	57.0	1.00		
Strength Training					
No	265	57.7	0.98	(0.77 – 1.29)	0.98
Yes	2349	57.8	1.00		
Impact					
No	902	53.9	0.78	(0.67 – 0.92)	0.003
Yes	1712	59.9	1.00		

Data table 10 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and whether the male participants encountered any pain in the knee region.

Data table 10. Knee Pain Yes / No - Males

	n	% pain	OR	95% CI	p value
Age					
<30	191	53.4	1.00		0.14
31-40	235	57.9	1.20	(0.82 – 1.76)	
41-50	106	66.0	1.70	(1.04 – 2.78)	
>50	61	50.8	0.90	(0.51 – 1.61)	
Training Volume - Hrs / Week					
1 – 5	108	57.4	1.00		0.74
6 - 10	290	56.6	0.97	(0.62 – 1.51)	
11 - 15	132	55.3	0.92	(0.55 – 1.53)	
>15	63	63.5	1.29	(0.68 – 2.45)	
Core Training					
No	392	53.8	0.67	(0.47 – 0.94)	0.02
Yes	201	63.7	1.00		
Flexibility Training					
No	367	54.8	0.77	(0.55 – 1.08)	0.13
Yes	226	61.1	1.00		
Strength Training					
No	54	51.9	0.79	(0.45 – 1.38)	0.41
Yes	539	57.7	1.00		
Impact					
No	219	55.3	0.88	(0.63 – 1.24)	0.47
Yes	374	58.3	1.00		

Data table 11 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and whether the female participants encountered any pain in the lower leg (shin, calf – Achilles, ankle, foot).

Data table 11. Lower Leg Pain Yes / No - Females

	n	% pain	OR	95% CI	p value
Age					
<30	534	55.6	1.00		0.000
31-40	968	55.5	0.99	(0.80 – 1.23)	
41-50	781	53.6	0.92	(0.74 – 1.15)	
>50	330	41.8	0.58	(0.44 – 0.76)	
Training Volume - Hrs / Week					
1 – 5	417	47.2	1.00		0.06
6 - 10	1394	54.3	1.33	(1.07 – 1.65)	
11 - 15	549	55.0	1.37	(1.06 – 1.76)	
>15	253	53.4	1.28	(0.93 – 1.75)	
Core Training					
No	1542	52.9	0.96	(0.82 – 1.13)	0.64
Yes	1071	53.8	1.00		
Flexibility Training					
No	1312	51.8	0.89	(0.77 – 1.04)	0.15
Yes	1301	54.7	1.00		
Strength Training					
No	265	55.5	1.11	(0.86 – 1.43)	0.44
Yes	2348	53.0	1.00		
Impact					
No	901	43.7	0.56	(0.48 – 0.66)	0.000
Yes	1712	58.2	1.00		

Data table 12 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and whether the male participants encountered any pain in the lower leg (shin, calf – Achilles, ankle, foot).

Data table 12. Lower Leg Pain Yes / No - Males

	n	% pain	OR	95% CI	p value
Age					
<30	191	59.7	1.00		0.05
31-40	235	51.5	0.72	(0.49 – 1.06)	
41-50	106	49.1	0.65	(0.40 – 1.05)	
>50	61	41.0	0.47	(0.26 – 0.84)	
Training Volume - Hrs / Week					
1 – 5	108	49.1	1.00		0.82
6 - 10	290	53.4	1.19	(0.77 – 1.85)	
11 - 15	132	54.5	1.25	(0.75 – 2.07)	
>15	63	50.8	1.07	(0.56 – 1.99)	
Core Training					
No	392	50.5	0.78	(0.55 – 1.10)	0.15
Yes	201	56.7	1.00		
Flexibility Training					
No	367	48.2	0.63	(0.45 – 0.88)	0.007
Yes	226	59.7	1.00		
Strength Training					
No	54	48.1	0.82	(0.47 – 1.44)	0.49
Yes	539	53.1	1.00		
Impact					
No	219	38.4	0.40	(0.28 – 0.56)	0.000
Yes	374	61.0	1.00		

Data table 13 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and the intensity of injury where a positive response indicates more than 1 day of unplanned rest in female participants.

Data table 13. Intensity of Injury (requiring at least 1 day of unplanned rest) - Females

	n	% unplanned rest	OR	95% CI	p value
Age					
<30	527	38.5	1.00		0.12
31-40	962	42.7	1.19	(0.96 – 1.48)	
41-50	768	37.6	0.96	(0.77 – 1.21)	
>50	324	37.7	0.96	(0.73 – 1.28)	
Training Volume - Hrs / Week					
1 – 5	410	43.2	1.00		0.25
6 - 10	1376	38.9	0.84	(0.67 – 1.05)	
11 - 15	543	40.9	0.91	(0.70 – 1.18)	
>15	252	36.1	0.74	(0.54 – 1.03)	
Core Training					
No	1518	39.3	0.96	(0.82 – 1.13)	0.63
Yes	1063	40.3	1.00		
Flexibility Training					
No	1294	38.0	0.87	(0.74 – 1.02)	0.08
Yes	1287	41.4	1.00		
Strength Training					
No	262	40.8	1.05	(0.81 – 1.37)	0.69
Yes	2319	39.6	1.00		
Impact					
No	886	39.5	0.99	(0.84 – 1.17)	0.88
Yes	1695	39.8	1.00		

Data table 14 illustrates the relationship between age, training volume, core training, flexibility training, strength training and impact activities and the intensity of injury where a positive response indicates more than 1 day of unplanned rest in male participants.

Data table 14. Intensity of Injury (requiring at least 1 day of unplanned rest) - Males

	n	% unplanned rest	OR	95% CI	p value
Age					
<30	190	34.2	1.00		0.008
31-40	231	37.2	1.14	(0.76 – 1.70)	
41-50	104	30.8	0.86	(0.51 – 1.43)	
>50	61	13.1	0.29	(0.13 – 0.65)	
Training Volume - Hrs / Week					
1 – 5	107	36.4	1.00		0.68
6 - 10	289	30.8	0.78	(0.49 – 1.24)	
11 - 15	129	31.8	0.81	(0.47 – 1.40)	
>15	61	36.1	0.98	(0.51 – 1.89)	
Core Training					
No	386	33.4	1.12	(0.72 – 1.61)	0.55
Yes	200	31.0	1.00		
Flexibility Training					
No	361	30.5	0.78	(0.55 – 1.11)	0.17
Yes	225	36.0	1.00		
Strength Training					
No	53	24.5	0.65	(0.34 – 1.24)	0.19
Yes	533	33.4	1.00		
Impact					
No	215	27.0	0.66	(0.46 – 0.96)	0.03
Yes	371	35.8	1.00		