Dance injury monitoring, strength and conditioning training for decreasing injury incidence for Chinese pre-professional dancers

DANCE INJURY MONITORING, STRENGTH AND CONDITIONING TRAINING FOR DECREASING INJURY INCIDENCE FOR CHINESE PRE-PROFESSIONAL DANCERS

YANAN DANG MSc, MA

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Abstract

The high prevalence of dance injuries affects elements of training, rehearsals, performance, and even the daily lives of those involved. Therefore, reducing and preventing dance injuries is an ultimate goal. Previous studies have evidenced that greater levels of physical fitness have been linked to decreased injury incidence and improved dance performance, whilst they had not been reviewed.

The systematic review, for the first time, systematically reviewed the efficacy of physical fitness training on dance injury. It included 10 studies that met the inclusion criteria from an initial 2450 publications. These studies offered physical fitness training for professional (n = 3) and pre-professional dancers (n = 7), participant sample size ranged between 5 to 62, ages from 11 to 27 years, and most participants were females. Assessment scores were classified as Fair (n = 1), Limited (n = 7), and Expert Opinion Only (n = 2) and risk of bias scores ranged from 22.7% to 68.2 %. After physical fitness training, 80 % of studies reported significant benefits in injury rate, the time between injuries, pain intensity, pain severity, missed dance activities and injury count. This review suggests that physical fitness training could have a beneficial effect on injury incidence in dance. The evidence is limited by the current study methodologies.

Based on this evidence, the following studies (studies 1-4) focused on improving the level of evidence in study design, dance injury tracking methods, physical fitness training content and load, and dance injury reduction. In addition, previous research has mostly focused on Western populations, with only a few studies examining Chinese dancers. Therefore, using exclusively Chinese dancers, the aims of this thesis were fourfold: (a) to investigate and compare injury prevalence, causes, and risk factors before and during the COVID-19 lockdown, (b) to develop a dance injury monitoring tool on a weekly basis and examine its efficacy of weekly reporting and respondent compliance, (c) to determine injury incidence and injury severity of Chinese full-time pre-professional dancers using the injury monitoring tool, and (d) to examine

the efficacy of strength and conditioning training on dance injury, physical fitness, and dance performance.

Study 1 investigated dance injury in 2086 full-time Chinese pre-professional dancers pre- and post-COVID lockdown. Self-reports revealed that injury prevalence dropped significantly from 39.6% to 16.5% during this period ($p<0.01$). During the lockdown, the injuries on the lower back, feet and shoulders decreased significantly ($p<0.01$), but the knee, ankle and groin joint injuries remained the same. Fatigue and the recurrence of an old injury remained reported as the top two perceived causes of an injury between the two periods.

Study 2 developed a weekly online dance injury monitoring tool and examined its efficacy. A total of 756 respondents from 16 different Chinese dance schools engaged in the survey. Over a two-semester period, the dropout rate was 70.1%, with student respondents under 18 years of age having a slightly lower drop-out rate than adult respondents (69% vs 71%). It was concluded that the researchers would need to weigh reduced completion rates (<100%) against data efficacy to achieve generalizability.

Study 3 determined dance injury incidence and severity in full-time Chinese pre-professional dancers using the injury monitoring tool developed in Study 2. A total of 450 individuals' data from 11 different schools were included in the analyses. The injury prevalence was 64.9%, and the injury incidence was 5.51 injuries per 1000 hours. Forty-eight percent of the injuries were minor severity and 41% were of moderate severity. Female dancers are at a higher risk of injury and reported higher levels of injury severity than male dancers ($p<0.001$).

Study 4 examined the effects of a strength and conditioning training intervention on dance injury, physical fitness and dance performance. A total of 89 full-time pre-professional dancers participated. Sixty-seven dancers volunteered for a 12-week strength and conditioning training intervention (2-session/week, 40-60-min/session), and 22 dancers acted as controls. The injury was self-reported using the

dance injury monitoring tool (Study 2). The intervention group significantly increased physical fitness ($p<0.001$), but their dance performance data remained unchanged ($p>0.05$). The intervention group reported lower injury prevalence (28% vs 15%, $p<0.001$) and injury incidence (8.09 vs 5.16 injuries per 1000hrs, $p<0.05$) than the previous year.

In conclusion, this thesis examined dance injury epidemiology following the COVID-19 arrival for a sizable sample size of Chinese pre-professional dancers and then determined injury incidence at a higher level of evidence using an innovative self-developed dance injury monitoring tool. Building on this, this thesis reinforced the positive effect of strength and conditioning training on dance injury incidence. The thesis has contributed to moving one step closer to reducing and preventing dance injuries and enriching the diversity of participants in dance injury studies.

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1. Introduction

1.1 Dance injury research

Dance injury has been the focus of clinicians and scientists for over six decades.[1,2] Most published data indicated that dancers have a high risk of injury with chronic injuries being more prevalent than acute,[3-17] mainly involving muscles and joints[8,13,17,18] on the lower back and lower extremities,[4,5,8-11,13,16-32] while the leading causes of dance injuries include fatigue, overwork and the reoccurrence of old injuries.[4,7,8,17,18,33-35]

Most of the aforementioned studies were mainly conducted in North America[15] and Western European countries, and only a handful took place in China. Furthermore, most Chinese dance-injury studies were published in Chinese, which were mainly conducted by dance-science students, and rarely constituted a peer-reviewed publication.[17] Although these published studies reported similar injury characteristics, there were no data on injury incidence (injuries/1000hrs) of Chinese dancers prior to 2019.[17]

1.2 The arrival of COVID-19

The unexpected arrival of the COVID-19 pandemic caused strict lockdowns and travel restrictions between different countries for about three years. Studies that have incorporated the lockdown period have focused on how dance can help the general population stay fit and healthy,[36-38] or how lockdown has changed pre-professional dancers' training and life.[39-44] The lockdown itself meant that pre-professional training institutions altered their face-to-face dance classes to online delivery, which was a great challenge for both students and teachers, as neither had any previous experience with such conditions.[39,41]

Although these online activities could never replace traditional dance classes, they

did provide a stimulus to innovate the dance curriculum and education.[42] Dance teachers had to quickly design their lessons to be carried out in a small space (3 to 5 m^2) and often on a wooden floor or tiled floor; this was accompanied by unstable internet connections, which led to low image quality that made their usual detailed movement feedback particularly challenging.[42] Man[43] and Weber[44] noted that the change in the training environment required "new rituals" and a reflection on what could be taught safely. Currently, there are no published data on how lockdown affected injury profiles in dancers.

1.3 Research methodology

Previous studies have employed different retrospective methods to record injury incidence and aetiology over varying time periods, diverse degrees of accuracy and detail of injury data have been noted. For instance, a number of studies investigated dance injury using one-off recall questionnaires over either 3-month,[9] 6-month,[15] or 12-month periods.[18,45] This leads to a wide range of injury prevalence from 3% to 95%[4,5,8-10,14,15,17,18,20,21,46] and injury incidence below 5 injuries per 1000 hours (dance exposure).[5,7,10-14,16,17,22,23,25,26,47-49]

With the increase of in-house medical teams within dance companies and some pre-professional schools, there has been an increase in prospective studies to record dance injuries.[16] Although these data are more accurate and detailed, the associated costs, such as the employment of a medical practitioner/team, have often limited the participant group to either professional ballet or modern dance companies or a few well-funded pre-professional schools.[16]

Based on the advantages and limitations of the methodologies mentioned above, a more suitable research method was needed that provides the detail of an inhouse medical team via a remote monitoring method. Certain studies have evidenced that using an online recall survey repetitively over a certain period of time could record the injury data weekly[12] or monthly,[11] but provided limited methodological insight.

1.4 Physical fitness intervention training

With the development of dance injury research, a number of studies have directly examined the effects of physical fitness training on dance injuries.[16,50-55] In these studies, strength and conditioning training were commonly used and appeared to be effective with outcomes reporting a decrease in pain intensity/severity,[52,53] injury count,[16,54] and injury incidence.[16]

Previous studies indicated that inadequate physical fitness levels, such as muscular strength[56,57] and muscular endurance,[8,58] have been cited as principal causes of dance injuries. As a result, it has been argued that optimal physical fitness for dancers may be as important as dance skill development.[29] Research has also revealed that supplemental physical fitness training has a positive impact on aesthetic dance performance,[50,55,59-65] though the strength of these studies were limited by sample size and level of evidence. These studies recruited participants from a number of different dance styles/genres that included ballet,[51,52,66] contemporary,[54,67,68] hip-hop,[50,52] danceSport,[55] and traditional Korean dance.[53] Dancers' attitudes to strength training have also changed, with fewer perceiving that it would have a negative effect on their body's aesthetics as was the previous misconception. However, there is still progress to be made before strength and conditioning training is considered a key element of dance and dance performance.[69]

1.5 Chinese dance education

The present thesis recruited participants who were full-time dance students, either from universities or affiliated middle dance schools in China. University students were on a 4-year course and the affiliation middle dance school students were on a 6 or 7-year course. Universities recruit dance students from pre-professional secondary schools with full-time training or high-school students with part-time training. Pre-professional secondary schools recruit students (11–12 years old) from primary schools or junior high schools.[70] Pre-professional training usually starts around the age of 11–12 years

with students training 11–17 hours a week until they are 18 years old; university students (18–22 years old) trained between 17 and 20 hours a week.

Dance training in China includes majors in Ballet, Contemporary, Sportdance, Musical Theatre (includes 6-year training in Chinese Folk dance, Contemporary dance and Musical Training in affiliated high school,[70] and 4-year training in undergraduate education[71]), but also Danceology (a general full-time course that includes training in Basic Ballet Training, Chinese Classic Dance, Chinese Folk Dance, Contemporary Dance, Dance Choreography, and Dance Theory), Chinese Classical Dance (sole specialization at a conservatoire), Chinese Folk Dance (sole specialization at a conservatoire), or Chinese Dance (a combination of classical and folk dance usually at a regular university).

1.6 Injury definition

The definition of injury has changed over time, from time-loss or medical attention definitions to more recent attempts that encompass all injuries irrespective of whether medical attention is needed or time taken off.[11,19] Previous studies reported an incidence of time-loss injuries between 1.46 to 4.4 injuries/1000hrs[13,14] and below 5 injuries/1000hrs[7,11,12] of inclusive injuries. That is in line with the results of Kenny et al. which argues that the time-loss injury definition[14,16,72] underestimates the injury burden in dance.[11,12] Most dancers will not stop dancing unless the injuries are severe,[18,73] and the outstanding characteristic of dance injury is not pain,[74] some dancers do not feel pain with posterior ankle impingement syndrome (PAIS) and flexor hallucis longus tendinopathy (FHL), they just experience a limitation in their of range of movement. Therefore, the present thesis employed an inclusive definition of dance injury that was adapted from the survey Fit to Dance 2 Dancers and Dance Students (2005). Dance injury was defined as a physical problem that happens while dancing, which manifests as a pain or discomfort resulting in modified participation, dysfunction, reduced range of movement, or the immediate cessation of dance activity.[45]

Furthermore, the previous study[17] highlighted the difficulties when participants had self-reported each injury, such as its severity (the number of days off and the time the injuries occurred) because of vague and inaccurate memories. Although the Visual Analogue Scale[52-54,75] and Numerical Pain Rating Scale[68] are often used to identify the severity of injury, they are subjective tools that lack internal consistency among participants. Moreover, the functional movement scale[68,76] in dance science research was used to assess disability[68,76] or physical fitness outcome[50,68,76] rather than injury severity, which would add extra pressure when dancers fill out long-term questionnaires. Therefore, a detailed severity description seemed more acceptable for dancers than the methods mentioned above. This thesis used injury severity that was a summary of all injuries and was categorized as minor (I felt pain/uncomfortable, but it did not affect my dancing), moderate (I had to adapt my movement or could not do specific actions), moderate to severe (I had to stop dancing but no more than 1 day), and severe (I could not dance 1 day or more).[45]

1.7 Systematic review

A number of previous systematic reviews have highlighted that dancers have a high incidence of injury with chronic injuries being more prevalent than acute.[3-7] Despite movement differences between dance genres, the most affected sites are the lower extremity and lower back,[17,20,30-32] with fatigue, overwork, and repetitive movement being reported as the main causes.[7,8,17,18,33] However, inadequate physical fitness levels, such as muscular strength[56,57] and muscular endurance,[8,58] have often been cited as principal causes of dance injuries. As a result, it has been argued that optimal physical fitness for dancers may be as important as skill development.[29]

Previous studies have highlighted the positive effectiveness of physical supplemental training on dance performance and injury risk but also emphasized their limitations (sample size, mostly in female dancers, low rigor, low level of evidence, et al.).[50] Although more studies have been suggested to examine the effects of

supplemental training on injury risk, only two studies have been found before March 2020. Therefore, it is necessary to systematically review previous studies to evaluate the efficacy of physical fitness training on dance injury. Notifying the strengths and limitations of previous studies to inform future research and make decisions about the design of the sub-studies in this present thesis with higher strength of recommendation and reject their limitations.

2. The Efficacy of Physical Fitness Training on Dance Injury: A Systematic Review

This review has been published.[55] Yanan Dang was the primary researcher in the study and set objectives, method design, carried out searches, assessment scores, and wrote the article.

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2.1 Introduction

Research over the past two decades has started to examine the association between physical fitness training and dance injuries.[33,77-79] Research also revealed that physical fitness increases even improve dance performance without any unwanted effects on the aesthetics of the art.[59,63,80] However, only a few studies directly examined the relationship between physical fitness training interventions and dance injury,[50] and the evidence has not been reviewed yet. Therefore, this present study aims to systematically review the efficacy of physical fitness intervention programs on dance injury across different dance genres and participant skill levels.

2.2 Materials and Methods

2.2.1 Search strategy

Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, 2020),[81] the following databases were searched: CINAHL, Cochrane Library, PubMed, Web of Science, MEDLINE, China National Knowledge Infrastructure (CNKI), and related journals such as Journal of Dance Medicine and Science (JDMS) and Medical Problems of Performing Artists (MPPA) were used to search peer-reviewed published articles in English or Chinese.

These electronic databases were searched using the Medical Subject Heading (MeSH) terms, free-text words, keywords, and subheadings: ("Physical Fitness [MeSH Terms]" OR strength OR condition * OR fitness OR power OR endurance OR mobility) AND (Injuries [MeSH Terms] or Injury) AND (Dance * OR Ballet OR "Hip Hop" OR Jazz).

A hand search of reference lists and citations to identify other studies was also conducted. The whole searching process occurred over three months, from March to June 2021.

2.2.2 Inclusion and exclusion criteria

Inclusion criteria incorporated peer-reviewed publications in English or Chinese. These articles had to deliver physical fitness intervention training to impact injury incidence in dancers, with no limitation of nature of the injury, injury sites, injury severity, dance genres, the levels of dance, gender, and age. All study designs were included from case studies to random controlled trials. Exclusion criteria comprised non-peer-reviewed sources such as books, conference proceedings, and thesis.

Database searches were downloaded into EndNote (ver. 20, Clarivate). Articles were removed if they did not directly relate to the inclusion criteria if it was not in either English or Chinese (Fig 2.1). There are two stages when screening articles: we screened all titles and abstracts (Stage 1) and then full texts were assessed for inclusion (Stage 2). Any discrepancies between the two reviewers (YD and MW) were discussed and mutually agreed decisions were reached. The selected articles were subsequently reviewed in full.

2.2.3 Methodological quality assessment

The included studies' designs were ranked according to the Oxford Centre for Evidence-Based Medicine.[82] Studies were further analyzed using Strength of the Evidence for a Conclusion (GRADE).[83] The GRADE evaluated five aspects: Quality, Consistency, Quantity, Clinical Impact and Generalizability, and which gave five outcomes: Good, Fair, Limited, Expert Opinion Only, and Not Assignable.[84] The risk of bias was evaluated using Kmet et al. checklist.[85] Studies were scored on 14-item that assessed the internal validity or the extent to which the design, conduct, and analyses minimized errors and biases. The assessment of the included studies was evaluated separately by two reviewers (YD and MW).

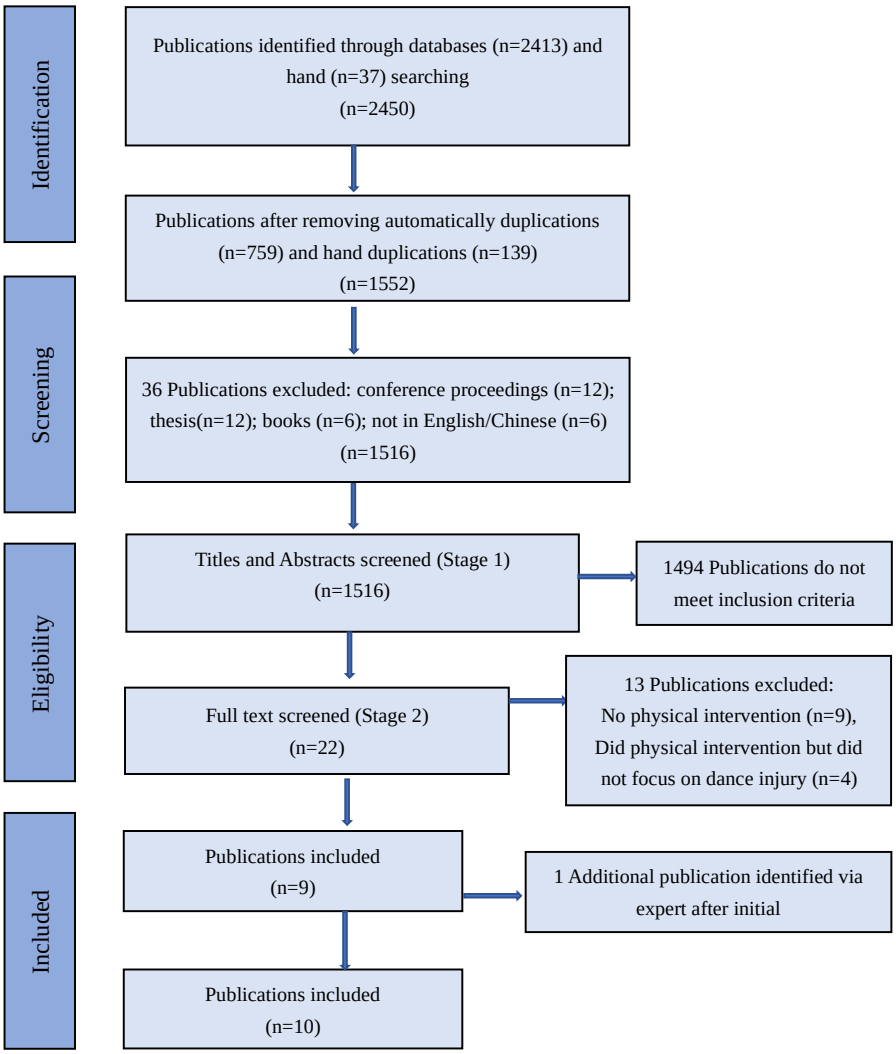


Figure 2.1 PRISMA Flow Diagram

2.3 Results

2.3.1 Descriptive information

A total of nine studies (1998 to 2021) met the inclusion criteria from an initial pool of 2450 publications, and a further one additional publication was identified via a reference review of the included studies (Fig 2.1). These ten studies offered physical fitness training for professional (n = 3) and pre-professional dancers (n = 7) whose dance genres were ballet (n = 7), contemporary (n = 3), DanceSport (n = 1), hip-hop (n

= 1), and Korean traditional dance (n = 1). The sample sizes ranged between 5 to 62, ages from 11 to 27 years, and most of them were females (F = 117–119; M = 65–69). However, only six studies provided information on the dancers' injury status[52,53,66,68,76,86] and affected sites[53,68,76,86] prior to intervention (Table 2.1).

2.3.2 Study design and assessment scores

The included studies had a range of methodologies, including two randomized controlled trial studies, one prospective randomized clinical trial, one uncontrolled trial, one mixed-methods quasi-experimental study, one non-randomized longitudinal study, and four cohort studies. These studies included four levels of evidence according to the Oxford Centre for Evidence Levels,[82] which were comprised of Level 1 (n = 1), Level 2 (n = 4), Level 3 (n = 3), and Level 4 (n=2).

Based on five aspects of GRADE, the mean scores ranged from 3.8[51,86] to 1.6,[16] and assessment scores were classified as Fair (n = 1), Limited (n = 7), and Expert Opinion Only (n = 2) (Table 2.1). The overall scores of the risk of bias to the method ranged from 68.2 % to 22.7 % (mean: 48.7 % ± 13.1 %) (Table 2.1, Appendices a and b).

2.3.3 Physical fitness tests and training

All studies did physical fitness tests pre- and post-intervention. The majority of them did muscular strength tests (n=7),[16,53,54,75,86-88] whilst other tests included stability[16,66,87] and balance,[51,66] mobility[16,51,76] and flexibility,[53] and cardiovascular endurance.[54,75,88]

These physical intervention training included strength training (n=8),[16,54,75,76,86-88] stability training (included balance training, motor control training, stabilization training, proprioception training) (n=5),[53,54,76,87,88] mobility training (n=2),[53,76] endurance training (n=2),[54,75] and agility training (n=1).[66]

Table 2.1 Included studies description, Strength of Evidence and Risk of Bias

Study	Cohort					Method		Strength of Evidence		Risk of Bias	
	Genre	Dance level	Age	Gender	N	Design	Condition pre-intervention	Mean	Mean ±SD	Acute score/ possible score	%
Long et al., 2021[66]	Ballet	Professional	23	M=2 F=4	6	Cohort	Un-injured	3	3±0.7	11/22	50
Vera et al., 2020[51]	Ballet	Professional	27	M=20 F=19	39	RCT	NR	4	3.8±0.5	15/28	53.6
Viktória et al., 2016[52]	Ballet and hip-hop	Pre-professional	13	NR	62	Cohort	Un-injured	3	2.8±0.8	12/22	54.6
Welsh et al., 1998[86]	Modern and Ballet	Pre-professional	19	M=1 F=7	8	Cohort	Back pain history but not current	4	3.8±0.5	5/22	22.7
Kline et al., 2013[68]	Ballet	Pre-professional	11-18	NR	5	Cohort	Back pain and radicular symptoms	3	3.2±0.5	8/22	36.4
Roussel et al., 2014[54]	Modern and Ballet	Pre-professional	20	M=6 F=38	44	RCT	NR	3	2.8±0.8	16/28	57.1
KiM et al., 2017[53]	Traditional Korean	Professional	24	M=3 F=10	13	RCT	Grade 2 unilateral hamstring strain	3	3±0	15/28	53.6
Mistiaen et al., 2012[75]	NR	Pre-professional	20	NR	27	Cohort	NR	3	3±0.7	12/22	54.6
Allen et al., 2013[16]	Ballet	Pre-professional	23-26	M=25-29, F=27-29	52-58	Cohort	NR	2	1.6±0.6	15/22	68.1
Chong et al., 2011[76]	DanceSport	Pre-professional	NR	M =8 F=12	20	Cohort	Ankle soft tissue injury	3	2.6±0.6	8/22	36.4
Summary			11-27	M=65-69 F=117-119	5-62			3	3.1±0.6		48.4±13.1

Age = average age or age range; N=Number; NR = Not Reported; M=Male; F=Female; RCT= Randomize Control Trail

Five studies reported their training methods were comprised of resistance training,[16,66,76] circuit training,[54,75] and cross-training.[16] In which there were twenty-four exercise movements offered in their physical fitness training (Table 2.2).

2.3.4 Physical fitness training load and outcome

The studies that did provide detailed interventions reported that they mainly lasted between 30-90 minutes per session (n=6),[51,54,66,75,76,88] 2-3 times per week (n=7)[51,53,54,66,75,86,88] for 4-16 weeks (n=8).[51,53,54,66,76,86-88] Two studies involved long-term interventions ranging between 6-36 months.[16,75]

Post-intervention testing reported significant improvements in physical fitness elements, including stability and balance,[66,87] strength,[53,75,87] flexibility,[53,76] and endurance.[75] Two studies reported non-significant improvements in strength from 14% to 151%[86,88] and another physical fitness parameters remained consistent (Table 2.2).

2.3.5 Physical fitness training and dance injury outcome

The majority of studies (80%) reported a positive improvement in injury reporting. The eight studies stated that the physical fitness interventions had a range of positive outcomes, for instance, a significant decrease (82 % reduction, $p = 0.002$) in injury rate,[51] pain intensity (ballet: 9 vs 1.3, $p = 0.004$; Hip-hop: 8 vs 2.8, $p = 0.002$),[87] pain severity (4.2 vs 2.1, $p = 0.017$),[53] and injury count (355 vs 174, $p < 0.01$; 5 vs 0, $p = 0.019$),[16,54] and also a significant in- crease in time between injuries (130 vs 219 days, $p = 0.028$).[51] Furthermore, two studies reported a non-significant decrease in the numbers of dance activities missed due to pain,[86] relief of symptoms.[88]

Two studies[66,75] used the SF-36 questionnaire to track injuries, neither reported overall change in SF-36 scores post intervention, but one noted a significant decrease in physical pain (83.2 vs 67.6, $p = 0.009$).[75] The other study[66] recorded no injuries during the study period.

Table 2.2 Physical Test, Intervention and Results

	Studies	Physical Fitness Test	Physical Intervention Training			Results		
			Training	Exercises	Intensity	Physical Fitness	Mean ±SD (pre/E vs post/C)	P value
1	Long et al., 2021[66]	Motor control test, balance test, and stability tests on knees and ankle, hip and upper extremity.	Agility and strength training	Bridges, planks, deadlifts, lunges, squats, step ups and jumping	2-time/week 30-minute 5-week	Balance	260.1±18.0 vs 291.6 ±30.5	0.028*
						Ankle and knee stability	119.6±12.3 vs 147.6 ±25.0	0.043*
						Upper extremity stability	25.4±3.2 vs 31.3 ±4.3	0.042*
2	Vera et al., 2020[51]	Balance test, turnout test, hypermobility test	Resistance training (with elastic bands or free weights)	+ Fire hydrants; Resistance band toe points, foot flexion and pointed eversion; Star drill; lower extremity stretching; Nordic hamstring; dead bird and dog; Prone leg lift; Glute kicks; Wall sits; Step-downs; Single-leg stance.	3-time/week 30-minute 4-week	NR	NR	NR
3	Viktória et al., 2016[52]	Static core strength test, motor control stability test.	Core strengthening and stretching, balance and lumbar motor control. Correct dance posture.	NR	NR NR 12-week	Core muscles static strength (Ballet)	58.9±30.5 vs 88.7 ±21.3	0.000†
						Core muscles static strength (Hip-hop)	67.6±32.5 vs 83.7 ±25.7	0.015†
						Lumbar motor control (Ballet)	5.3±0.3 vs 3.7 ±0.3	0.000†
						Lumbar motor control (Hip-hop)	4.0±1.3 vs 3.9 ±1.0	0.000†

4	Welsh et al., 1998[86]	Spine (back) extensor strength test.	Back strengthening (abdominal, rotary torso, hip and knee extensor, knee curl)	NR	2-time/week NR 7- to 10-week	Lumbar extensor strength	14% to 151%	NR
						Dancers' ratings of strength	2.5 vs 6.25	NR
5	Kline et al., 2013[68]	Core strength and endurance test	Traditional lumbar stabilization and core strengthening program	Plank, bridge	2-time/week 25-30-mins 6-week	Strength in positions	NR	NR
						Straight leg raise range (PROM)	85 vs 111	NR
6	Roussel et al., 2014[54]	Aerobic capacity test, lower limb explosive muscle strength test	Endurance, strength, proprioception, motor control training, circuit	Exercises on bicycles, steps, rowing machines, and dance-specific exercises	2-time/week 75-minute 16-week	Aerobic capacity	211.1±3.4vs 202.1 ±3.6	0.079
						Explosive strength	1.83± 0.03 vs 1.81 ±0.03	0.630
7	Kim et al., 2017[53]	Flexibility and isometric strength of the hamstring muscle test	Postural stabilization, Concentric and eccentric ROM	Static and active stretching, straight leg raising, leg curls, anterior and posterior pelvic tilt.	3-time/week NR 8-week	Flexibility and Strength	121.9±8.4 vs 139.6±5.9	<0.001†
8	Mistiaen et al., 2012[75]	Aerobic endurance test, explosive muscle strength of lower limbs test	A circuit (endurance and strength), "Start-To-Run" program.	Dance-specific exercises	3-time/week 90-minute 24 weeks	Aerobic power	2.3± 0.6 vs 2.4±0.6	0.025*
						Oxygen consumption	1.6 ±0.5 vs 1.7 ±0.5	0.045*
						Resistance level	129.6 ±40.5 vs 139.8 ±43.5	0.019*
						Strength increased	NR	NR
9	Allen et al., 2013[16]	Strength test (core strength and lower limbs), shoulder and trunk (rotary) mobility	Strength and conditioning (cross-training, resistance	Jumping and NR	NR NR 144-week	Functional Movement Screen	15 vs 13	>0.05

		test.	training).					
10	Chong et al., 2011[76]	AROM and PROM test	Ankle muscle strength (resistance training), ROM, proprioception	Ankle flexion and extension, Power bike exercise, closed-chain exercise, diagonal, heel lift, jumping, balance exercise on device	7-time/week ~75-minute 6-week	Ankle Functional score	57.6 ±8 .7 vs 89.3±7 .9	<0.001†
						AROM	21.5 ±5 .4 vs 59.7 ±15.2	<0.001†
						PROM	33.3 ±6 .1 vs 67.9 ±11.9	

* and † = improved significantly ($p<0.05$ and $p<0.01$, respectively); + = plus the exercises above; NR = Not Reported; all physical results report improvements with p value or not, except bold fonts; AROM and PROM = Active Range of Motion and Passive Range of Motion, respectively; E=Experiment group; C=Control group; SD=Standard Deviation;

Physical fitness interventions significantly decreased dancers' injury incidence across five different dance genres; Ballet,[16,51,54,86-88] Modern,[54,86] Hip-hop,[87] DanceSport[76] and traditional Korean[53] (Table 2.3).

2.3.6 Dance injury tracking methods

Eight studies defined dance injury[16,51,53,54,66,86-88] with 6 using a time-loss definition, including dance activities missed and symptoms forcing the student to interrupt classes[16,51,54,66,75,86]; and the other studies reported injury as pain, strain, spasms, pull, tingling, numbness, weakness, acute trauma, or overuse injury.[16,51,54,88]

The severity of dance injury was monitored using a number of scales that included the Visual Analogue Scale[53,54,75,87] and Patient Specific Functional Scale and Numerical Pain Rating Scale.[88] Injury incidence and aetiology were tracked using the Short Form 36-Questionnaire[54,75] and Hamstring Injury Questionnaire,[53] and clinician and dancer records (Electronic Medical Record System,[51] Self-record[86] and Injury Surveillance Program[16] and Ankle System Functional Score[76]). One study[66] also incorporated interviews with their study design (Table 2.3).

2.3.7 Intervention location, equipment and supervision

Seven studies reported where the intervention occurred these included the dance studio,[16,51,53,66] the clinic,[53,86,88] a rehabilitation laboratory, [76] home,[88] or pool.[16] Six studies had supervised interventions by either a physician,[86,88] physical therapist,[53,54,66,75,86,88] fitness trainer,[86] dance teacher/dancers[54,66,75]; while only one was un-supervised and used a booklet, graphic and video.[51] Finally, three studies did not report how the intervention was carried out.[16,76,87] The most popular item of equipment for the interventions was a resistance band[51,53,54,66,76] (Appendix c).

Table 2.3 The Methodology and Results of Dance Injury

Studies		Genres	Methodology of Dance Injury			Results of Dance Injury			
			Definition	Injury Tracking	Aspects	Mean ±SD		P value	Differences
						Pre/Con	Post/Exp		
1	Long et al., 2021[66]	Ballet	Time-loss	Interview	Time-loss	0	0	NR	× ND
2	Vera et al., 2020[51]	Ballet	Full-time lose, adaptation of NASA injury guidelines.	Electronic medical record system	Injury rate was 82% less	0.52-0.90	0.18	0.022*	√ Decreased
					Time between injuries	130	219	0.028*	√ Increased
3	Viktória et al., 2016[52]	Ballet	Low back pain	Visual analogue scale (VAS)	Pain intensity (Ballet)	9.0 ±18.2	1.3±3.3	0.004†	√ Decreased
		Hip-hop			Pain intensity (Hip-hop)	8.0±10.9	2.8±8.7	0.002†	
4	Welsh et al., 1998[86]	Modern and Ballet	The number of dance activities missed due to pain (time-loss)	The number of dance activities missed due to back pain	The numbers of dance activities missed reduced	NR	NR	NR	√ Decreased
5	Kline et al., 2013[68]	Ballet	Pain, strain, spasms, pull, tingling, numbness, weakness.	Patient Specific Functional Scale, Relief of symptoms Numerical Pain Rating Scale		NR	NR	NR	√ Decreased
6	Roussel et al., 2014[54]	Modern and Ballet	Acute trauma; repetitive stress in dancing; missed dance activities	VAS, Short Form 36-questionnaire	Less low back injuries (count)	5	0	0.019*	√ Decreased
7	Kim et al., 2017[53]	Traditional Korean	NR	Hamstring injury questionnaire, VAS	Pain severity (VAS)	4.2±1.2	2.1±0.9	0.017*	√ Decreased
8	Mistiaen et al., 2012[75]	NR	Symptoms forcing the student to interrupt classes (time-loss)	Medical and the short-form 36 questionnaires, VAS	The total score of the SF-36 remained unchanged	663±105	612.7±122.6	0.122	× ND
9	Allen et al., 2013[16]	Ballet	Time-loss (≥ 24 hrs), classified either as traumatic or overuse	Injury surveillance program (in-house physiotherapists)	Injury count	355	174	<0.01†	√ Decreased
					Injury incidence (M)	4.76	2.22	NR	√ Decreased
					Injury incidence (F)	4.14	1.81	NR	
10	Chong et al., 2011[76]	DanceSport	NR	Ankle Functional Score	Ankle circumference	26.4±2.9	24.8 ±2.8	<0.01†	√ Decreased

* and † = improved significantly ($p<0.05$ and $p<0.01$, respectively); ND = no difference after intervention; NR = not reported; C=Control group; Exp=Experiment group; Con=Control group; SD=Standard Deviation;

2.4 Discussion

This systematic review aimed to examine the efficacy of physical fitness intervention training programs on dance injury across different dance genres and participant skill levels. It was found that such programs led to decreased dance injuries.[16,51,53,54,66,75,76,87,88] Although 80 % of the identified studies reported a positive effect, the number of these studies (n = 7) and their sample size were rather limited. Furthermore, the quality of these studies was rated between Fair to Expert Opinion Only, and scores of the risk of bias ranged from 68.2 % to 22.7 %, with only two Randomized Controlled Trail studies.[51,54]

Although physical fitness training significantly reduced dance injuries across the included studies, no meta-analysis could be performed (heterogeneity) and therefore the evidence is based on few or individual studies. For instance, injury rate ($p<0.05$),[51] extended time between injuries ($p<0.05$),[51] reduced pain intensity ($p<0.01$),[87] relieved pain severity ($p<0.05$),[53] reduced injury count ($p<0.01$, $p<0.05$),[16,54] and decreased the circumference of swelling ankles ($p<0.01$).[76] However, the current level of evidence highlights the need for improved methodologies, such as using an inclusive injury definition and reporting full intervention details. Although six studies used a time loss as dance injury definition,[16,51,54,66,75,86] this could underestimate the injury burden as the majority of dance injuries are minor or moderate and do not require time away from dancing.[12,13]

The majority of studies had limited sample sizes, using convenience samples, seven studies had sample sizes smaller than 30 participants. No studies reported power analysis a priori, which weakens the generalizability of the link between physical fitness training and performance or injury risk.[50] Further, the lack of details regarding training frequency[16,87] and training load[16,53,86,87] means study replication or clinical implementation is impossible.

For a study to have a clinical perspective, the length of the exercise intervention and the number of participants was essential to provide relevance. Welsh et al.[86] recruited eight dancers for a 7-10 week back strengthening intervention training and reported a non-significant reduction in the numbers of dance activities missed from 16 to 4 sessions. In contrast, Allen et al.[16] recruited 52 to 58 dancers over three years and reported a significant reduction in injury counts from 355 to 183 in the second year. However, the later study lacked specific intervention protocols, as they implemented an individualized program approach. This study and another long-term study[16,75] were also limited due to their lack of a control group.

Vera et al.[51] attempted to implement a 52-week randomized controlled study with a professional ballet company setting. The authors reported an 82% decrease in injury rate and an extended period between injury episodes, but these results can't truly be put down to the intervention due to the low compliance (45% dropped out) and completion rate (4-week intervention). Home-based[88] or self-executed intervention with a handout outlining[66,75] using portable apparatus[53,66,88] is undoubtedly convenient but goes against the idea that unsupervised sessions[51] may be incorrectly executed.[50]

The majority of included studies (n=7) tested strength[16,53,54,75,86-88] and provided successful strength training interventions,[16,54,66,75,76,86-88] but only a couple evaluated cardiorespiratory parameters in their conditioning interventions.[54,75] However, previous research has shown that dance class and rehearsal are at a lower cardiorespiratory demand than dance performance.[53] During the performance, dancers work at close to their maximum capacities.[89] This reinforces a link between poor cardiorespiratory fitness, fatigue and injury incidence.[78,90-92] The lack of cardiorespiratory interventions within the included studies highlights the need for a more holistic approach to injury prevention.

Intervention frequency and duration ranged between 2-3 times per week[51,53,54,66,75,86,88] and 30-60 minutes per time,[50,51,54,66,88] which is often lower than other interventional regimens. Unless their injury prevents dancing, dancers usually

train 4-6 hours a day, 5-6 days[93] a week, and therefore a limited intervention can produce beneficial effects.[59,80]

Although the selected studies reported significant positive benefits for the use of physical fitness training as an intervention, they used a variety of scales with only pain intensity or injury severity in common.[53,54,75,87,88,94,95] These are both subjective scales, and more replicable methods are needed as the case in sports injury surveillance.[72]

The overall quality of included studies was relatively low. The majority demonstrated inadequate sample sizes,[51,53,66,76,86,88] weak design,[66,86,88] incomplete evidence,[51,53,86,87] and very poor execution.[51] Moreover, the methodological risk of bias is high. Although the purpose of their studies was easily identified, half of them failed to completely describe the purposes.[51,75,76,86,87] Some of them lacked inclusion/exclusion criteria of subject selection,[86] or their selection strategy was not ideal,[16,54,75,76] some didn't report the basic descriptive data (age or sex) of dancers,[75,87,88] whereas in some studies statistical analysis was not reported.[86,88] Therefore, the significant results reported in insufficient details with low evidence[51,53,66,76,86-88] lack validity.

2.5 Conclusion

The included studies suggest that physical fitness training could positively affect dance injury rate, injury intensity, injury severity, extend the time between injuries, and reduce injury count. However, the heterogeneity of the studies, the low sample sizes and weak methodological designs prevent a meta-analysis and therefore evidence is based on few or single studies. Therefore, more RCTs with high-quality designs are needed to strengthen the evidence on whether physical fitness training can positively affect injury incidence in dancers.

3. Thesis structure and aims

The aforementioned systematic review highlighted the fact that physical fitness training could have a beneficial effect on dance injury, but the evidence is limited by the study methodologies. Based on this evidence, the following studies (studies 1-4) focused on improving the level of evidence in study design, dance injury tracking methods, physical fitness training content and load, and dance injury reduction.

The thesis ultimately aimed to decrease dance injury incidence in Chinese pre-professional dancers. Accomplishing this goal requires dividing the thesis into several ordered and interconnected sub-studies, including investigating the characteristics of dance injury in Chinese dancers (study 1), self-developing a novel dance injury monitoring tool (study 2), determining injury incidence and severity in Chinese dancers (study 3), and examining the efficacy of physical fitness training on dance injury (study 4). The precise structural design is as follows:

Study 1 to 4 were built on the findings from a systematic review (Chapter 2) regarding the efficacy of physical fitness training on dance injury. Specifically,

Study 1 (Chapter 4) builds on the investigation methods of dance injury from the systematic review (Chapter 2). It adapts the questionnaire of the survey Fit to Dance 2 Dancers and Dance Students (2005) and utilises an updated injury definition. The study investigates the prevalence and risk factors of dance injury for Chinese dancers. Due to the unexpected arrival of the recent pandemic, the study compares differences in dance injury and its risk factors before and during COVID-19.

Study 2 (Chapter 5) builds on the systematic review (Chapter 2) and the study 1 (Chapter 4). Previous research, as highlighted in the systematic review (Chapter 2), has shown that injury epidemiology survey studies were of poor quality with inaccurate injury recall. Therefore, this study developed an online dance injury monitoring tool to be used on a weekly basis; the injury monitoring tool includes two questionnaires that

adapted from study 1 (Chapter 4), changing the survey period from a 12-month to 1-week and examining the efficacy of weekly reporting and respondent compliance.

Study 3 (Chapter 6) investigates injury prevalence, injury incidence, injury sites, and injury severity using the injury monitoring tool from the study 2 (Chapter 5). It monitors dance injury weekly for Chinese pre-professional dancers for over one academic year.

Study 4 (Chapter 7) is an attempt to develop a strength and conditioning training intervention, as the systematic review (Chapter 2) revealed that physical fitness training could decrease dance injury, given that strength and conditioning training is a popular method that is proven effective. At the same time, this study continues monitoring dance injury using the monitoring tool from Study 2 (Chapter 5) and Study 3 (Chapter 6).

The aims and hypothesis of each study are summarised as follows:

Study 1 (Chapter 4):

Aim: To investigate injury prevalence and risk factors of injury in Chinese full-time pre-professional dancers and compare injury prevalence, causes, and risk factors before and after the COVID-19 lockdown.

Study 2 (Chapter 5):

Aim: To develop a remote dance injury monitoring tool on a weekly basis and examine its efficacy of weekly reporting and respondent compliance.

Study 3 (Chapter 6):

Aim: To monitor dance injury over one-academic-year and to determine dance injury incidence and injury severity of Chinese full-time pre-professional dancers.

Study 4 (Chapter 7):

Aim: To examine the efficacy of strength and conditioning training on dance injury, physical fitness, and dance performance in Chinese pre-professional dancers.

4. Study 1: Prevalence and risk factors of dance injury during COVID-19: a cross-sectional study from university students in China

This study has been published.[45] Yanan Dang was the primary researcher in the study, and set objectives, study design, adapted questionnaire, recruited participants, carried out investigation, data analysis, and writing of the article.

Dang Y, Koutedakis Y, Chen R and Wyon M (2021) Prevalence and Risk Factors of Dance Injury During COVID-19: a cross-sectional study from university students in China *Front Psych* DOI: 10.3389/fpsyg.2021.759413

4.1 Introduction

The arrival of the coronavirus disease 2019 (COVID-19) forced nearly all pre-professional dancers to train and study from home due to the lockdown. Currently, there is no published data on how the lockdown affected injury profiles in pre-professional dancers. Before improving the evidence level in the following studies (studies 2-4), the researcher needs to know what happened to dance injury during this particular period. Therefore, this study aimed to compare injury prevalence, causes, and risk factors before and after the COVID-19 lockdown in Chinese pre-professional dancers.

4.2 Materials and Methods

This study used a cross-sectional survey design to recall injury prevalence and aetiology during the two distinct periods of time: the first was a 6-month period prior to COVID-19 lockdown and the second was a 6-month period during the lockdown where participants were restricted to their homes. Ethical approval was granted by the University of Wolverhampton (07/20/YD2/UOW, Appendix 1a).

The survey used the same questionnaire that was utilized in a previous survey on injury prevalence in Chinese dancers[17]; this had previously been adapted from the "Fit to Dance" Dancer and Dance Students Questionnaire.[8,21] There were 17 questions from the original questionnaire and 5 new and 5 repetitive questions to cover the "during COVID-19" period. This questionnaire focused on the student's basic information (personal data, dance education background, and dance training situation) before proceeding to their dance injury experiences in a 12-month period and during the COVID-19 period.

In the original 17 items, a few options were modified for this cohort. For instance, the options in question 1 were changed as an affiliation middle school student and a university student; for question 7, Chinese Classic Dance, Chinese Folk Dance, Chinese Dance, Sports Dance, and Dancology were added; the options of body

conditioning, strength training, and fitness training were synthesized as body conditioning (question 8); the questions of hours spent every week dancing (question 8) and the hours of sleeping (question 9) were asked for the two different time periods (before and during the COVID-19); and the option of the arms/hands was subdivided into hands, elbow, wrist, and upper arm, and/or forearm (question 15).

The five new questions included dance education background (question 5 dance background and question 6 current year/grade they are into); the degree of fatigue they are feeling during the two time periods (question 10, a Likert's scale 1–10). In the last part of the questionnaire, questions focused on online classes (questions 22 and 23) and dance floors (question 24) were added for the "during COVID-19" period. Finally, five items (25, 26, 27, 28, and 29) of dance injury experience were repeated for the "during COVID-19" period. The original version and the translated English version (Chinese) of the surveys are available as Appendices 1b and 1c, respectively.

4.2.1 Definition of Dance Injury

The present study used an inclusive injury definition, even if they didn't cause a cessation of training; and injuries were categorized as four levels.[45] Questions 15, 16, and 18 refer to the site, type, and perceived cause of injuries, respectively; respondents were asked to tick as many options as required to account for their different injuries over the defined time periods.

4.2.2 Inclusion Criteria

Inclusion criteria include the dance students who are receiving full-time dance training at a university, a technical secondary school, or a vocational dance school. The dance students who have graduated or are at the master's or a higher level were omitted.

4.2.3 Online Survey and Procedures

We distributed the survey using WenJuanXing (https://www.wjx.cn/), an online

platform that meets the European General Data Protection Regulation (2020). We used a snowball method to contact potential respondents, initially contacting dance teachers who forwarded the link to their students and also to other dance teacher colleagues. We also requested that students forward the survey link to their peers either at the same school or in a different institution.

This online survey started on September 13, 2020 and ended on November 10, 2020. The informed consent was on the first page of the questionnaire and comprised student consent for dance students over 18 years old and additional parent consent for the dance students who were under 18. The rest of the questionnaire was only accessible once they had given consent. The Chinese school year has two holiday periods, summer (July- September) and winter (January-March). Therefore, the pre-lockdown period (6 months) corresponded to the semester from September 2019 to February 2020 (inclusive) and the lockdown period (6 months) from March to August 2020 (inclusive).

4.2.4 Data and Statistical Analysis

STROBE reporting guidelines were followed.[96] Independent variables included the two reporting periods (pre-COVID and during the lockdown), dance genre (Dancology, Chinese Dance, DanceSport, Ballet, Chinese Folk Dance, Contemporary Dance, and Chinese Classic Dance), school level (USAMS—university students and those who were also trained full time at an affiliation middle school; USHS— university students who had previously studied part-time at high school; AMS—affiliate middle school students), anthropometric data (height, body mass, and age), and sex (male and female). Dependent variables included injury prevalence, cause, site, type and severity, and the perceived cause of injury.

Differences in injury prevalence, cause, site, type and severity, and the perceived cause of injury in different periods were assessed by Mann–Whitney *U*-test, Kruskal–Wallis *H*- test, McNamer test, Chi-squared test, and Wilcoxon Signed-Ranks test. Binary Logistic Regression was used to investigate the risk factors associated with

an injury event. The SPSS version 26 (SPSS, Inc., Chicago, IL, USA) was used for the aforementioned analyses, and the level for statistical significance was set at $p \leq 0.05$.

4.3 Results

After an initial analysis of the data, we decided to combine all Chinese dance styles (Classical Dance and Folk Dance) under the heading Chinese Dance. We removed all the weekly training hours data due to reporting inconsistencies. About 25 respondents reported injuries during the lockdown but missed answering the questions on injury incidence in the last 12-month period.

4.3.1 Participants

A total of 2,111 dance students initially responded to the survey, but 25 rejected the informed consent. The final total of 2,086 dancers [age 19 ± 2.40 years, height 168.4 ± 7.14 cm, body mass 53.2 ± 8.26 kg, and body mass index (BMI) 18.7 ± 2.1] was derived from 51 different institutions and comprised of 1,773 university students (20 ± 1.56 years, 168.5 ± 6.86 cm, 54.0 ± 7.92 kg, and BMI 18.9 ± 1.95) and 313 affiliation middle school students (15 ± 1.60 years, 167.5 ± 8.52 cm, 48.3 ± 8.48 kg, BMI 17.1 ± 2.25) while the majority of all respondents are women (n = 1,623, 77.8%). The main dance genres/major are Dancology (n = 1,183, 56.7%), Chinese Dance (n = 284, 13.6%), DanceSport (n = 214, 10.3%), Ballet (n = 123, 5.9%), Chinese Folk Dance (n = 107, 5.1%), Contemporary Dance (n = 81, 3.9%), and Chinese Classic Dance (n = 81, 3.9%). In the studied lockdown, 93% of the students (n = 1,938) received online classes from their schools for 3 (28.1%) to 4 months (33.6%), and they danced on the different floor types (28.2% wooden floor, 36.6% ceramic floor, 4% carpet, 18% Yoga mat, 12.1% personal dance studio floor, and 1% others). The complete data set is available at https://doi.org/10.6084/m9.figshare.16624207.v2.

The whole cohort (2,086 dance students) was further divided into three groups based on their dance training backgrounds and skill. The highest skilled group (USAMS)

was the group at the university and the group who had also trained full time at an affiliation middle school (n = 409, 8 ± 2.10 years training); the next group (USHS) was university students who had previously studied part-time at high school (USHS: n = 1,364, 2 ± 1.44 years training); and the last group (AMS) was AMS (n = 313, 3 ± 1.87 years training). Age, height, body mass, and BMI significantly differ in the three groups ($p < 0.01$). The AMS cohort was significantly younger than their university counterparts ($p < 0.05$) between groups. The USAMS reported more previous years of full-time training (PYT) than the other two groups ($p < 0.01$). Generally, men reported more years prior training (PYT) than women, with a significant difference for the USAMS group ($p < 0.01$; Table 4.1).

4.3.2 Injury Prevalence

Of 2,086 dance students, 1,145 reported injury prevalence over the entire last 12 months 54.9%, and 344 (16.5%) reported an injury during the lockdown. Injury prevalence before the lockdown was 39.6%, which was significantly dropped to 16.5% ($p < 0.01$) during the lockdown. There was no significant difference between men and women across the reporting periods ($p > 0.05$).

Compared to the university level groups ($p < 0.01$), the AMS group reported a higher injury prevalence (30.4%) during the lockdown but had a lower prevalence (26.2%) before the lockdown ($p < 0.01$). For Chinese Dance, the AMS group had a significantly higher prevalence (36.5%) than the USHS group during the lockdown (x^2 = 23.375, $p < 0.01$), but the former group reported a lower (27%) prevalence than the latter group (x^2 = 7.137, $p < 0.05$) before the lockdown. For those who are studying Dancology, the AMS group reported a higher injury prevalence (41.7%) than the other two groups during the lockdown (x^2 = 21.430, $p < 0.01$) (Table 4.2).

Table 4.1 Respondent Descriptive Data: Anthropometrics and Dance Training Background

	Whole cohort		AMS		USAMS		USHS	
Group (n)	**2086**		**313**		**409**		**1364**	
Age†	19.2±2.40		14.9±1.60 (A<UA†)		19.8±1.71 (UA<UH†)		20.0±1.51 (A<UH†)	
Height†	168.4±7.14		167.5±8.52 (A<UA†)		169.2±6.76 (UA>UH*)		168.3±6.88 (A<UH*)	
Body mass†	53.2±8.26		48.3±8.48 (A<UA†)		54.0±7.85		54.0±7.95 (A<UH†)	
BMI†	18.7±2.10		17.1±2.25 (A<UA†)		18.8±1.81		19.0±1.99 (A<UH†)	
PYT	3.2±2.80		2.8±1.87 (A<UA†)		7.7±2.10 (UA>UH†)		1.9±1.44	
Gender	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Group (n)	463	1623	89	224	90	319	284	1080
Age	19.1±2.74	19.2±2.89	14.6±1.70	15.0±1.55*	20.3±1.91†	19.6±1.63	20.1±1.57	20.0±1.49
Height	177.0±7.56†	165.9±4.65	173.5±11.57†	165.1±5.36	178.1±5.25†	166.7±4.72	177.8±6.17†	165.8±4.42
Body mass	62.6±9.40†	50.5±5.46	53.4±11.20†	46.3±6.06	64.4±7.36†	51.1±5.01	64.9±7.43†	51.1±5.06
BMI	19.9±2.75†	18.3±1.71	17.6±2.84*	17.0±1.94	20.3±2.13†	18.4±1.45	20.6±2.51†	18.6±1.60
PYT	3.3±3.04	3.1±2.72	3.1±2.02	2.8±1.8	8.3±2.26†	7.5±2.03	1.8±1.45	1.9±1.44

Please note that *p<0.05; †p<0.01. AMS/A: Affiliation Middle School students; USAMS/UA: University but previous trained at affiliate school; USHS/UH: University but previous trained at high school; BMI: Body Mass Index; PYT: Previous years of training (full-time).

Table 4.2 Dance Injury Prevalence in Two Different Periods (%)

Genres	Backgrounds	Before Lockdown		During Lockdown	
Dancology (n=1183)	AMS	27.8%	**43.3%†**	**41.7%†**	14.9%
	USAMS	45%	(Be > Du) †	15.6%	
	USHS	43.5%		13.6%	
Ballet (n=123)	AMS	16.5%	25.2%	22.7%	20.3%
	USAMS	**60%†**		12%	
Contemporary Dance (n=81)	AMS	80%	43.2%	20%	13.5%
	USAMS	47.8%	(Be > Du) †	8.7%	
	USHS	37.7%		15.1%	
Chinese Dance (n=451)	AMS	27.0%	36.1%	36.5%†	**23.5%†**
	USAMS	40.6%	(Be > Du) †	24.2%†	
	USHS	**39.8%***		**13.4%**	
DanceSport (n=214)	AMS	41.7%	33.6%	8.3%	7.9%
	USAMS	35.9%	(Be > Du) †	5.7%	
	USHS	32.2%		8.7%	
Others (n=34)	AMS	38.5%	38.2%	23.1%	26.5%
	USAMS	37.5%		37.5%	
Total (n=2086)	AMS	**26.2%**	**39.6%†**	**30.4%†**	**16.5%**
	USAMS	43.5%†		16.4%	
	USHS	41.5%†		13.3%	

"Chinese Dance" included Chinese Classic Dance and Chinese Folk Dance; *p<0.05; †p<0.01. "T": Total of injured dancers. "Be" and "Du": Before and During lockdown.

4.3.3 Injury Severity

In the two sub-periods, students reported a higher prevalence of minor and moderate injuries than moderate–severe and severe injuries ($p < 0.01$). However, compared to before the lockdown period, the prevalence of moderate-to-severe injuries increased by 4.1% ($x^2 = 4.019$, $p < 0.05$) during the lockdown period. The USAMS group reported more moderate-to-severe injuries before the lockdown ($x^2 = 6.863$, $p < 0.01$) than the USHS group but no significant difference during the lockdown. Approximately 14.5% of all respondents reported that their injuries resulted in days off from dancing; days lost to severe injury were similar among the three groups in the two periods (Table 4.3).

4.3.4 Tissue Injury and Sites

Respondents reported a higher prevalence of muscle and joint/ligament injuries than bone and tendon injuries ($p < 0.01$) in the two periods. The prevalence of muscle injuries was higher than that of joint/ligament injuries before the lockdown ($p < 0.01$), but the prevalence of both was the same during the lockdown (47 vs. 46.5%). Muscle injuries decreased by 15% during the lockdown compared to before the lockdown ($U = 127{,}797$, $z = -3.177$, $p < 0.01$) (Table 4.4).

The top six reported injury sites were the lower back, knees, feet, ankles, shoulders, and groin/hip-joint in the two sub-periods. During the lockdown, the injuries on the lower back ($p < 0.01$), feet ($p < 0.01$), and shoulders ($p < 0.01$) decreased significantly compared to before the lockdown period. However, knees, ankles, and groin/hip did not vary significantly despite an overall drop in injury prevalence. The USAMS group reported a significantly higher prevalence on the lower back ($p < 0.05$) than the other two groups while for the AMS group, it was the groin/hip-joint injuries ($p < 0.05$) in the two periods (Table 4.5).

Table 4.3 Injury Severity in Two Periods (%)

Severity	Backgrounds	Before Lockdown		During Lockdown	
Minor†	AMS	39.0%	46.5%	39.0%	43.4%
	USAMS	42.7%		40.3%	
	USHS	48.8%		46.7%	
Moderate†	AMS	50%	47.8%	48.4%	45.6%
	USAMS	55.1%		50.8%	
	USHS	45.2%		42.3%	
Moderate to Severe	AMS	9.8%	10.4% (Be < Du) *	12.6%	14.5% (MS > S) *
	USAMS	15.7%†		16.4%	
	USHS	8.8%		14.8%	
Severe	AMS	13.4%	9.9%	12.6%	9.0%
	USAMS	10.7%		10.5%	
	USHS	9.2%		6.6%	
Days lost	Total groups	46.8±63.23		34.8±39.83	

"Be" and "Du": Before and During lockdown; "MS & S": Moderate to Severe and Severe injuries. *p<0.05; †p<0.01.

4.3.5 Injury Causes

During the lockdown, the recurrence of old injury (37.2%), fatigue (33%), and insufficient warm-up (26.5%) were still the top perceived causes while respondents reported a significant increase of an unsuitable floor ($p < 0.01$), a cold environment ($p < 0.05$), and set/props ($p < 0.05$) as the causes for their injury. Between-group analysis highlighted that the USAMS group reported that their causes were the recurrence of an old injury in the two sub-periods ($p < 0.05$). During the lockdown, the AMS group reported an increase in "accident" as being the cause of injury ($p < 0.05$; Table 4.6).

4.3.6 Injury Risk Factors

The developed binary logistic model had an overall prediction accuracy of 85.9% before the lockdown and 87.2% during the lockdown. There was no significant difference between the predicted results and actual survey results ($p > 0.05$), indicating that the models have a strong efficacy.

The Wilcoxon Signed Ranks test indicated that the student fatigue ($Z = -11.145$, $p < 0.01$) decreases (from 5 ± 2.36 to 4.43 ± 2.29) but the hours of sleep increase (from 7.3 ± 1.57 to 7.9 ± 1.82) significantly ($Z = -16.869$, $p < 0.01$) during the lockdown than the period before ($p < 0.01$). Binary Logistic Regression analysis showed that fatigue was a negative risk factor of injury during the lockdown ($B = 0.173$, $p < 0.01$), every degree increases in fatigue approximately increase the risk of injury prevalence by 1.189 times (OR = 1.189, 95% CI: 1.114– 1.270). Furthermore, the reported number of hours of sleeping on a night had a significantly positive influence ($B = -0.116$, $p < 0.01$) on injury prevalence with every extra hour of sleep potentially decreasing the injury by 0.89 times (OR = 0.890, 95% CI: 0.818–0.968) during the lockdown. Furthermore, the AMS group reported no significant fatigue difference ($Z = -1.861$, $p > 0.05$), but the other two groups reported a lower fatigue degree during the lockdown period (USAMS: $Z = -8.168$, $p < 0.01$; USHS: $Z = -8.159$, $p < 0.01$).

Table 4.4 Tissue Injury in Two Periods (%)

Tissue	Backgrounds	Before Lockdown		During Lockdown	
Muscle†	AMS	45.1%	61.5%	48.4%	47.0%
	USAMS	61.8%†	(M>J) †	47.8%	(Be > Du) †
	USHS	63.8%†		54.4%	
Bone	AMS	17.1%	17.2%	14.7%	16.0%
	USAMS	22.5%		23.9%	
	USHS	15.6%		13.7%	
Joint/Ligament†	AMS	51.2%	50.7%	50.5%	46.5%
	USAMS	46.6%		43.3%	
	USHS	51.9		45.6%	
Tendon	AMS	15.9%	11.9%	6.3%	11.1%
	USAMS	12.4%		17.9%	
	USHS	11.1%		11.0%	
Other	AMS	11.0%	7.0%	7.4%	5.8%
	USAMS	9.0%		6.0%	
	USHS	5.8%		5.0%	

“M” and “J”: Muscle and Joint/Ligament injury; “T”: Total of injured dancers; “Be” and “Du”: Before and During lockdown. *$p<0.05$; †$p<0.01$.

Table 4.5 Injury Sites in Two Periods (%)

		Arms	Hands	Elbow	Wrist	Shoulders	Neck	U back	L back	Ribs	Pelvis	Groin/Hip	U legs	Knees	L legs	Ankles	Feet
Before Lockdown	C	**8.8**	**6.2**	**7.4**	**9.4**	**16.1**	**10.7**	**7.0**	**45.4**	**1.7**	**5.3**	**14.4**	**15.9**	**32.5**	**7.5**	**24.0**	**30.4**
	A	6.1	6.1	4.9	7.3	7.3	6.1	6.1	37.8	1.2	6.1	28.1†	8.5	23.2	6.1	28.2	22.0
	UA	6.2	4.5	5.1	9.6	14.6	14.0	6.3	53.4*	1.7	3.4	14.0	9.0	34.8	5.1	19.1	29.2
	UH	10.1	6.7	8.5	9.7	17.8*	10.3	7.4	44.0	1.8	5.8	12.5	19.1†	33.0	8.5	24.9	32.0
During Lockdown	C	**12.5**	**7.0**	**8.1**	**6.7**	**7.3†**	**7.3**	**4.7**	**29.1†**	**1.2**	**2.6***	**10.5**	**8.4†**	**29.9**	**5.5**	**23.6**	**18.9†**
	A	6.3	4.2	3.2	6.3	6.3	2.1	5.3	29.5	0.0	4.2	20.0†	5.3	28.4	0.0	15.8	14.7
	UA	14.9	6.0	7.5	4.5	6.0	10.5*	9.0*	38.8*	1.5	1.5	7.5	10.5	29.9	6.0*	26.9	22.4
	UH	14.8*	8.8	10.9*	7.7	8.2	8.8	2.8	25.3	1.7	2.2	6.6	9.3	30.8	8.2†	26.4*	19.8

“A”: Affiliation Middle School students; “UA”: University but previous trained at affiliate school; “UH”: University but previous trained at high school; “C”: Whole Cohort; *p<0.05; †p<0.01.

Table 4.6 Injury Causes in Two Periods (%)

Different Periods	Different training backgrounds	Fatigue	Limited/bad flexibility	Unsuitable floor	Cold environment	Insufficient warm up	Insufficient cool down	New/difficult choreography	Repetitive movement	Partnering work	Incorrect technique/training	Ignoring early warning signs	Lack the sense of self-protection	Recurrence of old injury	Inadequate diet/hydration	Set/props	Costume/shoes	Rehearsal schedule	Accident	Others
Before	C	**36.1**	**24.2**	**9.9**	**5.7**	**29.1**	**10.1**	**8.5**	**10.4***	**1.9**	**22.5†**	**13.0**	**28.5†**	**40.1**	**2.9**	**2.3**	**3.2**	**3.9**	**19.3**	**1.1**
	AMS	37.8	28.0†	11.0	2.4	28.0	9.8	2.4	4.9	0.0	23.2	12.2	28.0	28.0	1.2	0.0	3.7	2.4	17.1	4.9
	UAMS	43.8*	12.4	9.6	8.4	19.7	9.0	14.6†	12.9*	3.4	19.7	14.6	25.8	53.9†	3.4	1.7	4.5	3.9	18.0	1.1
	USHS	33.4	27.4†	9.9	5.3	32.2†	10.4	7.6	10.4	1.8	23.3	12.5	29.3	37.5	3.0	2.8	2.7	4.1	20.0	0.5
During	C	**33.0**	**19.2**	**31.1†**	**9.3***	**26.5**	**12.8**	**7.6**	**6.7**	**0.6**	**15.7**	**10.2**	**20.1**	**37.2**	**2.0**	**4.7***	**1.2**	**2.6**	**16.9**	**0.3**
	AMS	37.9	16.8	25.3	5.3	27.4	11.6	6.3	7.4	0.0	14.7	6.3	21.1	37.9	3.2	3.2	1.1	2.1	22.1*	1.1†
	UAMS	35.8	14.9	29.9	6.0	22.4	7.5	11.9	3.0	3.0*	11.9	10.4	14.9	55.2*	3.0	3.0	1.5	4.5	25.4*	0.0
	USHS	29.7	22.0	34.6	12.6	27.5	15.4	6.6	7.7	0.0	17.6	12.1	21.4	30.2	1.1	6.0	1.1	2.2	11.0	0.0

"AMS": Affiliation Middle School students; "USMAS": University but previous trained at affiliate school; "USHS": University but previous trained at high school; "C": Whole Cohort; *p<0.05; †p<0.01.

Respondents indicated that if they suspect an injury, they will take pain killers (10.6%) and continue to dance but carefully (43.7%). Binary Logistic Regression analysis indicated that behaviours, such as taking pain killers ($B = 0.596$, $p < 0.05$) and continuing to dance, however carefully ($B = 0.589$, $p < 0.001$) can approximately increase injury prevalence almost two times (OR = 1.814, 95% CI: 1.145–2.874 and OR = 1.801, 95% CI: 1.308–2.480, respectively) in the lockdown period.

Most of the Chinese dance students (70.7%) reported that their dance teachers made time available for a cooldown after dancing. Before the lockdown, timing being set aside for a cooldown by teachers was shown to have a significant positive influence ($B = -0.349$, $p < 0.05$) on injury prevalence, which could decrease by 0.705 times (OR = 0.705, 95% CI: 0.509–0.978). At the same period, age was a negative factor for injury prevalence ($B = 0.234$, $p < 0.01$), with each year older increasing the risk of injury by 1.263 times (OR = 1.263, 95% CI: 1.168–1.366).

4.4 Discussion

The purpose of this study was to examine injury prevalence, causes, and risk factors in Chinese pre-professional dancers before and during the COVID-19 lockdown. To our knowledge, this study is the largest dance injury survey in terms of participant numbers, which has replicated the established methodologies (i.e., questionnaire), thereby allowing appraisals with available data.[8,17,97,98] For instance, contrary to a previous study on Chinese dancers which revealed that men demonstrate a higher injury prevalence than women,[17] which was not replicated in the current survey. It is noteworthy that this lack of sex difference in injury prevalence in pre-professional dancers has been previously confirmed.[99]

The main finding was that compared to before the lockdown, injury prevalence significantly dropped from 39.6 to 16.5% ($p < 0.01$) during the lockdown. The binary logistic model used for the purposes of this study highlighted a positive benefit of

decreased feelings of fatigue and longer hours of sleep on the reduced injury prevalence during the lockdown period. Fatigue has been repeatedly reported as the main injury cause.[8,17,21,77,93,100-102] Getting adequate sleep has previously been linked to a decreased fatigue degree with a concomitant decrease in injury prevalence.[103] Teachers reported that the hours spent on dance training did not change during the lockdown period, but the intensity of the class was limited because students did not have the space to "travel" while dancing (the allegro section of a dance class). Thus, the reduced feelings of fatigue and longer sleep hours could explain why injury prevalence dropped significantly during the lockdown.

A lower fatigue degree of the university groups (USAMS and USHS) ($p < 0.01$) made a positive contribution to a drop in injury prevalence during the lockdown. The AMS cohort, on the other hand, reported a consistent feeling of fatigue ($p > 0.05$), and a higher percentage of accidents ($p < 0.05$) across the two lockdown periods could explain no decrease in its injury prevalence. Meanwhile, the other two older groups reported reduced feelings of fatigue, the younger AMS group possibly had less effective coping strategies, and therefore the lockdown period affected them more.[104]

This survey is the first to report injury prevalence in Dancology major (n = 1,183), which is a very important major in pre-professional Chinese dance training. The Dancology and Chinese Dance students reported the highest injury prevalence in the current survey, the latter genre's injury prevalence also increased by 17% (before the lockdown) to 30% (during the lockdown) since the 2018 survey.[17] These two majors had a significant decrease in injury prevalence between before and during the lockdown period. This could be due to the diversity of their training background, both previous full- and part-time training and often a limited number of years of previous training. The injury data from the ballet genre cohort supports this concept as almost all ballet students came from a full-time ballet training background and had the longest years of previous training; in this cohort there was little difference in injury prevalence between the before and during lockdown periods. The possibility that years of previous full-time

training could be a possible injury factor needs further analysis and study.

The present data also revealed a decreased prevalence of minor and moderate injuries but a significant increase in moderate to severe injuries during lockdown. Thus, the present finding could be linked to dance students' physical deconditioning due to the reduced training load experienced during the lockdown.[42] Indeed, Angioi et al.[77] indicated that increased severity of injuries was often associated with a reduced level of lower body muscular power.

In line with previous studies,[4,17,105,106] we found that muscle and joint/ligament injuries remained the main type of injuries and that this did not change during the two sub-periods (i.e., before and during lockdown). The main injury sites of the knees, ankles, and groin/hip joint also remained unchanged in the two studied periods, but injuries on the lower back, feet, and shoulders decreased significantly in the lockdown period. There was no obvious reason for an injury decline in these sites given that the "reoccurrence of an old injury" did remain the main perceived cause, whereas "unsuitable floor" as a possible cause of injury increased in the lockdown period. Nevertheless, this finding contradicts with what might be expected, which would be a positive association between an unsuitable floor and injuries on the lower limbs and back.[107,108] Previous research on dance floors has reported that the modifiability/mechanical properties of the dance floors (construction of different stages and class floors) greatly influence injury rates,[47,109-112] though no study has examined the effect of dancing at home on tiles or concrete.

The fact that ~14.5% of all respondents reported that their injuries resulted in days off from dancing, supporting the notion that using a time-loss definition for injury could underestimate injury burden[12] and may not be suitable for determining injury prevalence.[6] Thus, we recommend that scientists should find an appropriate methodology to try to collect authentic data from the surveys that recognize a time-off training, modified-movement training, or reduced training due to an injury.

It is reasonable to assume that the present results may have been influenced by methodological limitations. For example, although respondents were asked to report the number of hours of training in a week before and during the lockdown, the data were inconsistent and therefore omitted. However, 25 dance students only reported their injuries during the lockdown period but missed to answer the question that "whether you had an injury in the last 12 months?"

4.5 Conclusion

Within the limitation of this study, it was concluded that, although injury prevalence dropped significantly during the first COVID-19 lockdown in Chinese dance students, the main injury characteristics remained the same. Decreased fatigue and longer hours of sleep could explain the aforementioned drop in injury prevalence during the lockdown. However, injury severity increased possibly due to deconditioning and reduced training load experienced during the lockdown. The main injury sites such as the knees, ankles, and groin/hip-joint also remained unchanged in the two studied periods, but the lower back, feet, and shoulders decreased significantly in the lockdown period. Because of different training environments, the unsuitable floor (tiles or concrete) increased significantly as a main perceived cause of injury; but the recurrence of old injury and fatigue remained as the top two causes during the lockdown. Further studies are needed to investigate how dance training changes affect injuries to offer an effective intervention.

5. Study 2: Online dance injury monitoring: The efficacy of weekly reporting and respondent compliance over a 30-week period

This study has been published.[113] Yanan Dang was the primary researcher in the study, and set objectives, adapted questionnaire, carried out survey, collected and analysed data, and writing of article.

Dang Y, Koutedakis Y, Chen R and Wyon M (2023) Online Dance Injury Monitoring: The Efficacy of Weekly Reporting and Respondent Compliance Over a 30-Week Period. *J Dance Med Sci. DOI:* 10.1177/1089313X231177172

5.1 Introduction

Study 1 (Chapter 4) investigated dance injury characteristics in Chinese dancers and revealed that the main injury characteristics remained the same during the COVID-19 lockdown period in Chinese pre-professional dancers. However, Study 1 was designed as a retrospective study, and the level of evidence could be higher. Thus, we created an online dance injury monitoring tool by adapting the Dancer and Dance Student Questionnaire[8] from a 12-month recall survey, into a one-week recall that was sent out to dance students on a weekly basis. As the time-loss injury and medical attention injury have been shown to underestimate the injury burden in dance,[12] a more inclusive definition of this parameter was used for the purpose of this present study. The present study aimed to examine the efficacy of a remote weekly self-report injury incidence and aetiology tool.

5.2 Methods

Ethical approval was granted by the University of Wolverhampton (07/20/YD2/UOW, Appendix 1a).

5.2.1 Definition of Dance Injury

The present study used an inclusive injury definition, even if they didn't cause a cessation of training; and injuries were categorized as four levels (Introduction).[45] A new injury was defined as an injury that just occurred, while an old injury was classified as any injury that happened in the recent past and still affects the dancers.

5.2.2 Monitoring tool development

The online monitoring tool was based on the "Fit to Dance 2" Dancer and Dance Students Questionnaire (2005); this used in the second national inquiry into dancers' health and injury in the UK and has been applied in many published studies over 15 years.[18] The main adaptation from the original Fit to Dance survey was the recall period

being reduced from 12-month to 1 week. The tool was split into 2 surveys; the first survey asked for complete injury history, and the second survey was sent to each respondent on a weekly basis. It focused on new injuries that occurred in the current week and whether injuries that occurred in previous weeks were still affecting their dancing. Both questionnaires asked for dance students' basic anthropometric information, training and well-being condition, injury information, and treatment/rehabilitation in a week.

5.2.3 Questionnaires

There were 23 questions that fell into 4 different sections in both questionnaires. The first section focused on general information (Q1-4); the second section concentrated on training and well-being (Q5-9). The third section focused on injury incidence and aetiology (Q10-19); this used a question tree design where an initial response would either lead to a series of questions or skip them if they were not applicable. We thought this will help to reduce respondent fatigue of having to complete frequent questions. Question 10 focused on injury incidence in the previous week and injury site from 16-site options (Q11). For each injury they could select new or old injury (Q12); if a new injury was selected then detailed injury (13-19) and treatment or rehabilitation (Q20-23) questions appeared (Table 5.1).

In both surveys if no injury occurred (Q10) then the survey finished (Q11-23 are hidden) thereby making it shorter for the respondent. The second questionnaire was designed a little differently, the 4 anthropometric questions were only asked in the first week of each term; questions 1-11 and 19-23 were the same as the first week questionnaire. Questions 12-18 were adapted so if for question 12, "old injury" was selected, question 13-18 will be hidden; but if "new injury" was selected then questions 13-18 appeared (Table 5.1). This section could be completed multiple times to take into account each injury incidence. Two questionnaires in English and Chinese are available as appendices 2a, 2b, 2c, and 2d.

Table 5.1 Question variation between the two questionnaires

Parts	Content	Design	Questions	Content	**1st week**	**Weekly**
1	General information	Required	Q 1-4	Student number, school's name, dance genres and grade	✓	✓
2	Training and well-being condition	Required	Q 5-9	Training hours, the intensity of exercise, fatigue scale, sleep quality and eating condition	✓	✓
3	Injury details and the causes of injury	Required	Q 10	Injury prevalence (injured or not)	✓	✓
		Depending	Q 11	Injury sites (n=16)	✓	✓
		Depending	Q 12	New or old injury on each site	✓	✓
		Depending	Q 13-18	Injury on each site (the side of each injury site, tissue of injury, injury frequency and times, injury severity, injury happened in which dance activity and what kind of training)	✓	*
		Depending	Q 19	Causes of injury	✓	✓
4	Treatment	Depending	Q 20-23	If received treatment, what type of help, how many sessions, its effect (1-10)	✓	✓
Extra	Anthropometric	Required	Q 1-4	Gender, age, height and body mass	✓	×
	Informed consent	Required			✓	×

Please note that "*" means these questions depend on question 12; "✓" are included questions; "×" are excluded questions.

5.2.4 Distribution of the questionnaire

We distributed the questionnaire weekly on an online platform WenJuanXing (https://www.wjx.cn/), and then this platform generated links to questionnaires. Y.D. copied these links and sent them to participants on the social software Wechat (https://www.wechat.com/). Both these two software meet the European General Data Protection Regulation (2020).

Y.D. recruited respondents by introducing the objective and value of this online survey to dance teachers and students on Wechat to attract them; once they accepted this survey, YD asked if it is possible to invite more of their friends or classmates to engage with the survey.

5.2.5 Informed consent in the questionnaire

Each respondent completed informed consent, including parental consent for the respondent under 18 years old, before the rest of the questionnaire was accessible.

5.2.6 Online dance injury monitoring and procedure

Before the respondents could enter the questionnaire, they had to sign an informed consent and were reminded that their account names would be recorded for data tracking purpose. Each respondent could only fill out the questionnaire through one unique access account, and each account could only be completed once.

Weekly reminders were sent out from YD to dance teachers and students via Wechat at the end of each week for the second questionnaire (Friday/weekend). New respondents could start the survey at any time, starting with the first questionnaire and continuing with the second. All online data were downloaded each week into Excel and injury reporting was recorded against each respondent's account name.

The online survey was opened for Chinese full-time dance students from

September 2020 to July 2021; for participants under the age of 18 years old, the process was supervised by their dance teacher.

5.2.7 Data analysis

A software engineer wrote a program to create a unique identification code (UIC) for each individual that was based on their account name, student number, and school name. The PI (YD) had access to both the individual's name and contact details, whilst the rest of the research team could only see the participants' UIC. This enabled PI was able to send reminders to individual participants with missing data. All data were analyzed using descriptive statistical analysis within Excel; this included calculating completion/dropout rates.

5.3 Results

A total of 756 respondents engaged with the survey over a 30-week academic year from 16 dance schools; the first semester was 13-week, and the second was 17-week. In the first week of the first semester, 559 started and a further 64 new respondents started in week 2 of the first semester and 56 in the first week of semester 2. By week 30, 226 respondents were engaging with the survey. Over one academic year, there were 271 students for Affiliated Middle Schools (AMS), under 18 years old, and 485 university students (US) over 18 years old.

There was a drop-out of 70.1% from a maximum of 756 students that engaged with the survey. Students under 18 had a slightly lower drop-out rate than adult students (68.6% vs 70.9%). The attrition rate at the end of the first semester was 58.8%, 47.5% for the AMS group and 58.8% for the US group-separately (Figure 5.1).

Figure 5.1 Participant drop-out rate by week and age category

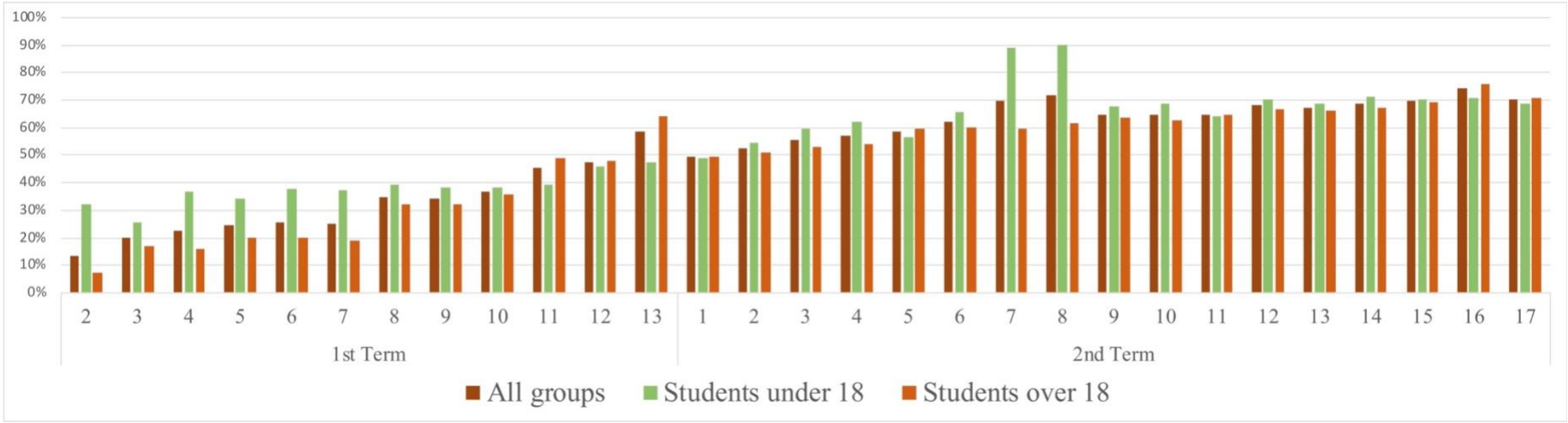
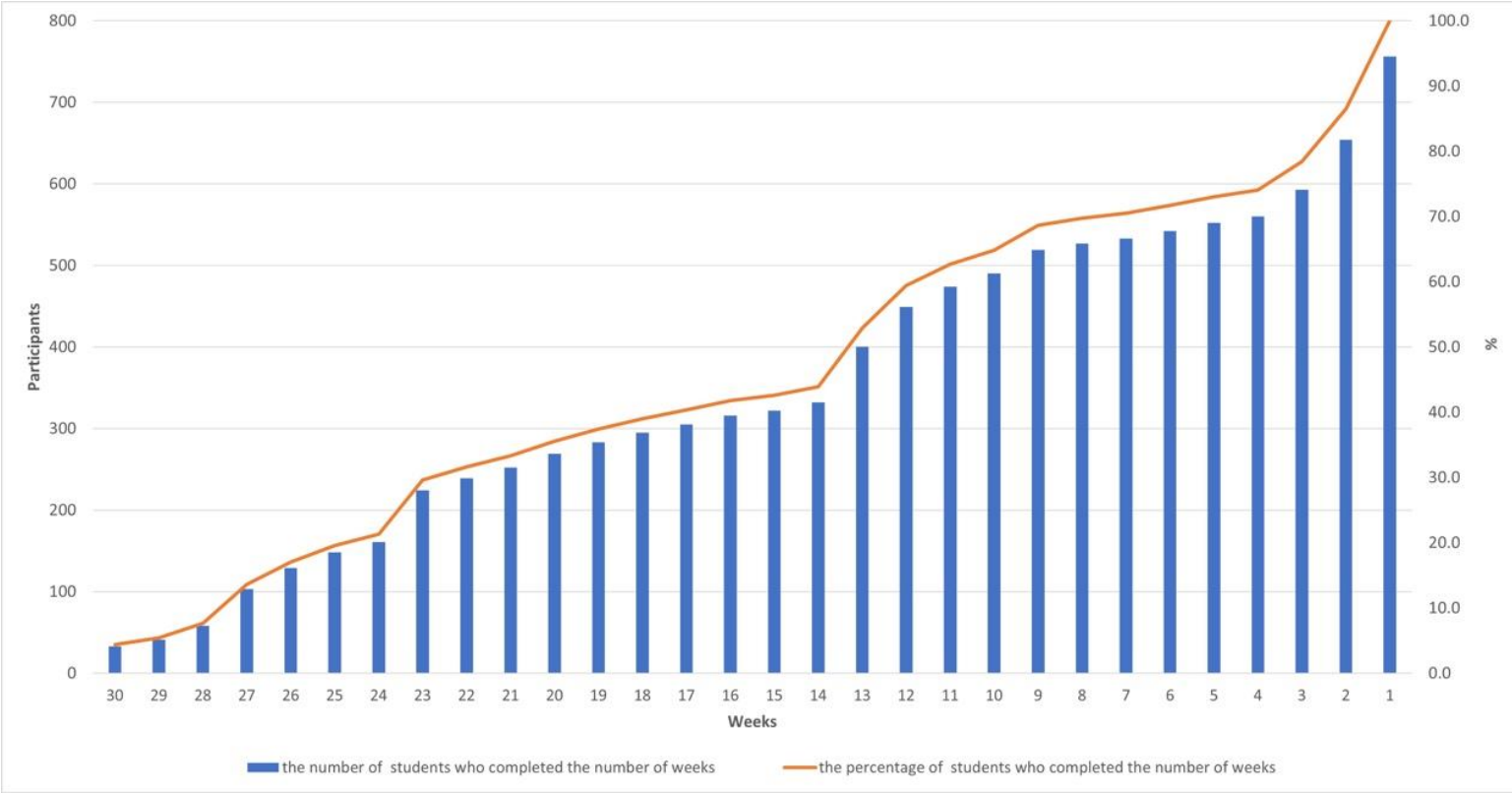


Figure 5.2 Participant compliance over an academic year: absolute and relative number of completed weeks



There were 33 respondents (4.4%) who completed all 30 weeks of the survey, 41 completed 29 weeks, 58 completed 28 weeks, 103 completed 27 weeks, 129 completed 26 weeks, and 148 completed 25 weeks (Figure 5.2).

5.4 Discussion

This study examined the efficacy of a remote self-report injury incidence and etiology tool. Over one 30-week academic year, there was a drop-out of 70.1% from a maximum of 756 students that engaged with the survey; students under 18 had a slightly lower drop-out rate than adult students (68.6% vs 70.9%).

Injury surveillance systems have been used for many years in sports and dance,[16,72] but most of them used injury definitions, time-loss or medical attention,[16,72] that underestimate injury incidence and occurred in well-fund institutions.[16,72] The current tool used an inclusive definition[45] and the design allowed access from respondents from multiple institutions.

The present study used the same recall period as Kenny et al.[12,19] (weekly) but shorter than Van Winden et al.[11] (monthly). Potentially the shorter recall period will help improve the accuracy of reported data, especially regarding cause and severity. The detrimental aspect of high frequency survey completion requirements is respondent fatigue and apathy. Kenny et al. (97% completion rates) and we, to a lesser degree, overcame this by engaging dance teacher supervision and reminder emails. By using a question tree we also reduced the number of questions respondents had to complete each time.

Although the present study reported a higher drop-out rate (70.1%) than 2 previous studies whose drop-out rates were 6.45%[19] (10 students dropped out) and 3%[11] (4 students dropped out), it recruited more respondents in a peak (n=756) than the aforementioned ones (n=184, n= 134). Furthermore, Van Winden et al.[11] included the data from respondents who completed a minimum of 30% of the questionnaires in their

whole survey period, whilst Kenny et al. just reported they excluded the missing weeks from analyses.[19] Using these above inclusion criteria, from van Winden and Kenny et al., the current survey would accept data from 519 and 756 respondents respectively (Figure 5.2). However, such low inclusion criteria potentially compromise the data quality, thus future surveys need to establish a higher quality of data inclusion criteria.

The previous surveys each recruited respondents from a local dance institution; this allowed a very focused reminder system to reduce missing data points.[19] The present study was more open and led to the participants from 16 different schools engaging with the survey. The primary researcher was located in a different continent, potentially reducing the effectiveness of reminder emails and further reflected in drop-out rates. In the current study noted that respondents who received teacher engagement, those under 18years old, had a slightly lower dropout than those who didn't (US participants) (Figure 5.1).

In this present study, the drop-out rate increased with the length of the survey period; at the end of the first semester, the drop-out rate was 58.8%, and it increased to 70.1% at the end of the second semester. Therefore, researchers would need to weigh reduced completion rates (<100%) against data efficacy to achieve generalizability. More studies are needed to practice dance injury monitoring tools to reduce errors to obtain a higher quality of data and facilitate the development of injury prevention strategies in dance.[72]

5.5 Limitations

The research team noted 2 limitations in tracking respondents. Firstly, respondents didn't correctly fill in their identifiers as this had to be done manually, and secondly, a few respondents (particularly those under 18 years old) changed their usernames. All of these increased the difficulty of respondent tracking and data combination.

5.6 Conclusion

This study examined the efficacy of a weekly self-report injury incidence and aetiology survey. Although the present study reported a high drop rate (70.1%) than previous online injury surveys, it recruited more respondents from multiple institutions. The results highlight the benefit of a reminder system and teacher engagement for decreased drop-out rates. The present study allows researchers to determine the effect of inclusion criteria on respondent numbers and the potential effect on data quality. Therefore, researchers would need to weigh reduced completion rates (<100%) against data efficacy to achieve generalizability.

6. Study 3: Injury incidence and Severity in Chinese pre-professional dancers: a prospective weekly monitoring survey

This study has been published.[114] Yanan Dang was the primary researcher in the study, and set objectives, carried out survey, collected and analysed data, and writing of article.

Dang Y, Koutedakis Y, Chen R, Wyon M. Injury incidence and Severity in Chinese pre-professional dancers: a prospective weekly monitoring survey. *Journal of Science and Medicine in Sport.* 2023.

6.1 Introduction

A novel dance injury monitoring tool was developed in Chapter 5 (Study 2), which offered an opportunity to obtain dance injury data in Chinese dancers at a higher level of evidence than Chapter 4 (Study 1). Therefore, the aim of this study was to investigate the dance injury incidence and severity in full-time Chinese pre-professional dancers.

6.2 Methods

Ethical approval was granted by the University of Wolverhampton (07/20/YD2/UOW, Appendix 1a).

6.2.1 The definition of dance injury

The present study used an inclusive injury definition that was categorized into four levels (Introduction), and new and old injuries were defined in Study 2.[45,113]

6.2.2 Injury monitoring

Participants were instructed to self-report injuries on a weekly basis during the monitoring period using a remote dance injury monitoring tool.[113] Its questionnaire distribution method, informed consents design, and reminder sending time were reported in Study 2. The online survey was opened for Chinese full-time dance students from September 2020 to July 2021.[113]

6.2.3 Inclusion and Exclusion criteria

The inclusion criteria required participants to be preprofessional dancers (age 12 yrs +) in full-time vocational dance training in a Chinese dance school or university and native Chinese speakers.

Based on pilot data,[113] weekly recall surveys were suggested to establish a higher quality of data throughout a study period; thus only data from participants with

a 90% weekly completion rate were analyzed. Participants who missed completing 3 consecutive weeks of the survey were also excluded from the analysis. Only two contemporary dancers engaged in the second-semester survey; thus, their weekly data in injury prevalence were removed.

6.2.4 Data analyses

All weekly data for each respondent were combined by a software engineer through creating unique reference codes using their account names, students' numbers, and schools' names. Dance exposure, injury prevalence, injury incidence, and injury severity were calculated weekly basis, rather than over a year, as different dance schools had differing semester start dates and length of study periods. An injury was counted as one incidence, if it was repetitively reported on the same site over weeks. Injury Prevalence (IP) was calculated as the number of students who reported an injury divided by the total number of participants; this was calculated for both the whole survey period, and weekly (Weekly Injury Prevalence, WIP). Injury incidence was taken as the number of injuries per 1000 dance hours. Injury severity was calculated for each of the 4 severity categories as a percentage across the whole survey period and on a weekly basis.

All data were analysed using descriptive statistical analysis within Excel and the SPSS version 28 (SPSS, Inc., Chicago, IL, USA). One-sample Kolmogorov-Smirnov test was used to examine whether the data were normally distributed. Mann-Whitney U test was used to analyse differences in age, height (cm), body mass (kg), BMI, weekly exposure (hours), and injury incidence between sex and different dance levels, while the Kruskal-Wallis H test was used to analyse these data per dance genre. Chi-square test was used to evaluate differences in IP between males and females, among dancers with different levels, and in diverse dance genres. Wilcoxon Signed-Rank Test was used to explore differences in weekly injury severity over 30 weeks between levels, sexes and genres.

6.3 Results

A total of 756 individuals from 16 different dance schools participated in the current survey over a 30-week academic year. After excluding data from 306 respondents who missed three consecutive weeks and did not achieve a 90% completion rate, 450 respondents from 11 different schools were included in the analysis (Appendix 3a). This included 210 respondents who completed at least 22 surveys over two semesters, and 240 completed at least 9 surveys in the first semester.

The 450 respondents included 110 Affiliation Middle School (AMS) students who were under 18-year-old (age 15 ±1.33yrs, height 167.9 ±6.16 cm, body mass 50.4 ±5.65 kg, BMI 17.8 ±1.26), and 340 University Students (US) over 18-year-old (age 20 ±1.19yrs, height 168.2 ±6.37 cm, body mass 54.8 ±9.29 kg, BMI 19.3 ±2.83); 79.8% of participants were females (n=359) (Appendix 3b). The 450 respondents derived from six dance genres: Dancology (n=222), Ballet (n=11), Contemporary dance (n=12), Chinese dance (n=126), DanceSport (n=59), and Musical Theatre (n=20) (Appendix 3c).

6.3.1 Weekly exposure

Weekly dance exposure for the full cohort was 32.2 hours. However, the AMS group reported less dance exposure than the US group [29.3hrs (95%CI 26.6, 32.1) vs 33.2hrs (95%CI 31.4, 34.9), $p<0.05$]. Contemporary dance students spent longer hours in dance (41.2hrs, 95%CI 31.7, 50.8) than the other 5 genres ($p<0.05$), followed by Dancology (33.7hrs, 95% CI 31.5, 35.9), Ballet (32.4hrs, 95% CI 20.7, 44.2), Chinese dance (32.2hrs, 95% CI 29.6, 34.9), DanceSport (28.3hrs, 95% CI 24.6, 32.0), and Musical Theatre (21.8hrs, 95% CI 15.3, 28.4). No sex difference for exposure was found in the full cohort, sub-groups and the six genres ($p>0.05$) (Appendix 3c).

Table 6.1 Injury incidence and days off due to severe injuries

	Full cohort (n=450)		AMS (n=110)		US (n=340)	
Injuries	1157		188		969	
Injuries/1000hrs	5.51±8.11		3.39±4.64		6.20±8.85*	
IP	64.9%		63.64%		65.3%	
Days off (the number of students)	33		13		20	
Days off (in total)	575		449		126	
Days off per dancer	17.4±28.35		34.5±39.92		6.3±4.01	
Sex	Male (n=91)	Female (n=359)	Male (n=23)	Female (n=87)	Male (n=68)	Female (n=272)
Injuries	165	992	19	169	146	823
Injuries/1000hrs	3.39±5.53	6.05±8.57†	1.53±2.84	3.88±4.91*	4.01±6.07	6.74±9.35*
IP	55%	67.4%*	43.5%	69%*	58.8%	66.9%
Days off (the number of students)	6	27	1	12	5	15
Days off (in total)	32	543	2	447	30	96
Days off per dancer	5.3±5.05	20.1±30.71	2±0	37.3±40.43	6.0±5.34	6.4±3.70

Please note that AMS means Affiliation Middle School dance students; UNI means University dance students; IP means Injury Prevalence; "*" and "†" mean $p<0.05$ and $p<0.01$, respectively.

6.3.2 Injury Prevalence and Incidence

Sixty-five percentage of our respondents (n=292) reported at least one dance injury. Female students demonstrated higher IP than their male counterparts in the full cohort ($p<0.05$) and the AMS group ($p<0.05$) (Table 6.1). The IP over the 30-week period in six genres was significantly different ($p<0.001$); ballet dancers reported the highest IP (90.9%, $p<0.01$), and then contemporary respondents reported significantly higher IP (83.3%, $p<0.05$) than the other four genres (Appendix 3d). The pattern of weekly injury prevalence (WIP) in each genre over the 30-week period was compared with the full cohort group, and the highest WIP in each genre was reported in the first three weeks of the first semester (Appendix 3d).

A total of 1157 injuries were reported, with an overall injury incidence of 5.51 injuries per 1000 hours. The US group demonstrated a higher injury incidence (6.2 vs 3.39 injuries/1000hrs, $p<0.05$) than the AMS group. Female students reported higher injury incidence than males in the full cohort (6.05 vs 3.39 injuries/1000hrs, $p<0.01$), in the AMS group ($p<0.05$), and in the US groups ($p<0.05$), but no sex difference in each dance genre ($p>0.05$). A significant difference was also noted between the six dance genres ($p<0.001$): ballet reported the highest injury incidence (8.01 injuries/1000hrs) compared with the other 5 genres ($p<0.05$); Dancology: 7.47 injuries/1000hrs, Contemporary Dance: 4.94 injuries/1000hrs, Chinese dance: 3.67 injuries/1000hrs, Musical Theatre: 4.14 injuries/1000hrs, and DanceSport: 2.18 injuries/1000hrs (Table 6.1 and Appendix 3e).

Table 6.2 Injury severity

	Full cohort (n=450)		**AMS (n=110)**		**US (n=340)**	
Minor	46.9%		24.3%		57.4%†	
Moderate	42.5%		53.7%†		37%	
Moderate to severe	5.6%		10.5%†		3.4%	
Severe	5%		11.5%†		2.2%	
Sex	Male (n=91)	Female (n=359)	Male (n=23)	Female (n=87)	Male (n=68)	Female (n=272)
Minor	58.8%†	44.4%	37.9%*	23.5%	59.5%	56.5%
Moderate	37.3%	43.8%	43.9%	54.4%†	37.5%	37.2%
Moderate to severe	1.8%	6.1%†	9.1%	10.5%†	1.5%	3.9%*
Severe	2.1%	5.6%†	9.1%	11.6%†	1.6%	2.5%

Please note that AMS means Affiliation Middle School dance students; UNI means University dance students; IP means Injury Prevalence; "*" and "†" mean $p<0.05$ and $p<0.01$, respectively.

6.3.3 Injury severity

Respondents reported primarily minor (46.9%) and moderate (42.5%) injuries across each subgroup. Comparing AMS and US sub-groups, adolescent students reported significantly higher percentages of moderate injuries (53.7% vs 37%, $p<0.001$), moderate to severe injuries (10.5% vs 3.4%, $p<0.001$) and severe injuries (11.5% vs 2.2%, $p<0.001$). The older group reported more minor injuries than the young group (57.4% vs 24.3%, $p<0.001$).

Compared to male students, females reported more moderate injuries for the AMS group (54.4% vs 43.9%, $p<0.001$), more moderate to severe injuries for the full cohort (6.1% vs 1.8%, $p<0.01$) and each subgroup (AMS: 10.5% vs 9.1%, $p<0.001$; US : 3.9% vs 1.5%, $p<0.05$), and more severe injuries for the full cohort (5.6% vs 2.1%, $p<0.001$) and the AMS group (11.6% vs 9.1%, $p<0.001$). Males reported more minor injuries than females in the full cohort (58.8% vs 44.4%, $p<0.01$) and the AMS sub-group (37.9% vs 23.5%, $p<0.05$) (Table 6.2).

Thirty-three respondents (7.3% of the full cohort) reported a total of 575 days off due to severe injuries, and these were female AMS dancers (12 respondents, 447 days off) (Table 6.1). Students from the Musical Theatre ($p<0.01$) and Chinese Dance ($p<0.05$) reported higher rates of severe injuries than the other genres; the former reported more severe injuries than the latter (28.5% vs, 6%, $p<0.001$) (Appendix 3f).

6.3.4 Injury sites

The main anatomical sites with the highest injury incidence were knees (0.89 per 1000hrs), lower back (0.80 per 1000hrs), feet (0.58 per 1000hrs), groin (0.56 per 1000hrs), shoulder (0.49 per 1000hrs) and ankle (0.41 per 1000hrs). The AMS sub-

Table 6.3 Injury incidence in main injury sites

	Full cohort (n=450)		AMS (n=110)		US (n=340)	
Shoulders†	0.49		0.20		0.59†	
Lower back	0.80		1.23		0.67	
Groin*	0.56		1.02*		0.41	
Knees†	0.89		0.75		0.93†	
Ankles	0.41		0.39		0.41	
Feet†	0.58		0.36		0.66†	
Sex	Male (n=91)	Female (n=359)	Male (n=23)	Female (n=87)	Male (n=68)	Female (n=272)
Shoulders*	0.21	0.56†	0.00	0.25*	0.28	0.66*
Lower back*	0.35	0.92*	0.19	1.50	0.41	0.73
Groin*	0.25	0.64	0.53	1.15	0.15	0.48*
Knees†	0.37	1.02†	0.06	0.93	0.48	1.05†
Ankles	0.34	0.42	0.17	0.44	0.39	0.42
Feet	0.69	0.56	0.17	0.41	0.86	0.60

Please note that AMS means Affiliation Middle School dance students; UNI means University dance students; IP means Injury Prevalence; "*" and "†" mean $p<0.05$ and $p<0.01$, respectively; all figures are in the number of injuries per 1000 hours.

group reported a higher incidence rate for the groin (1.02 vs. 0.41 injuries/1000hrs, $p<0.05$) than the US group, but the US sub-group was significantly higher for knees (0.75 vs 0.93 injuries/1000hrs, $p<0.01$); feet (0.36 vs 0.66 injuries/1000hrs, $p<0.01$) and shoulders (0.2 vs 0.59 injuries/1000hrs, $p<0.001$).

Female students reported higher injury incidence than males for the lower back for the full cohort (0.92 vs 0.35 injuries/1000hrs, $p<0.05$) and the AMS sub-group (1.5 vs 0.19 injuries/1000hrs, $p<0.05$), knees for the full cohort (1.02 vs 0.37 injuries/1000hrs, $p<0.001$) and sub-groups (US: 1.05 vs 0.48 injuries/1000hrs, $p<0.01$; AMS: 0.93 vs 0.06 injuries/1000hrs, $p<0.05$), shoulder for the full cohort (0.56 vs 0.21 injuries/1000hrs, $p<0.01$) and the US sub-group (0.66 vs 0.28 injuries/1000hrs, $p<0.05$), and groin in the US sub-group (0.48 vs 0.15 injuries/1000hrs, $p<0.05$) (Table 6.3 and Appendix 3g).

6.4 Discussion

This study aimed to determine dance injury incidence and severity in full-time Chinese pre-professional dancers using a weekly remote self-report injury tool. To our knowledge, this is the first study reporting prospective injury incidence for Chinese dancers. Most published studies from western populations indicated that dance injury incidence was below 5 injuries per 1000 hours.[7,11-14,17] The present study used an inclusive injury definition and reported injury incidence of 5.51/1000hrs, which is significantly higher than that from previously published data (4.4 injuries/1000hrs[14] and 1.46 injuries/1000hrs[13]) and supports the concept that the time-loss injury definitions underestimate the injury burden in dance.[12]

The highest WIP in each genre was found to be in the first three weeks of semester one and may be linked to a suddenly increased training load after returning from the summer holiday.[99] This wasn't repeated in the second semester, possibly

because the initial three weeks of semester two were online dance training (weeks 14-16) due to the COVID-19 lockdown. The latter is supported by a previous study on a similar participant group (i.e., Chinese dancers) which revealed that the injury prevalence percentage dropped significantly during the COVID-19 lockdown.[45] A possible explanation might be that since dancers' training occurred at home in a smaller space (3-5 m^2), the training load was reduced due to the confines preventing large jumps and traveling sequences.[42]

Most previous studies indicated that there is no significant sex difference in injury prevalence,[5,45] injury incidence,[10,13,14,25,26,99,115] or severity[13]; and some studies found male dancers with higher injury prevalence,[6,17] incidence[14,24] and severity[14] than their female counterparts. However, contrary to the aforementioned findings, the present study is consistent with a few studies that female dancers self-reported higher rates of injury prevalence,[14] injury incidence[116-118] and higher levels of injury severity[117] than male dancers.

Females reported higher IP than males, this phenomenon could be linked to increased risk factors such as the delayed onset of growth and maturation, delayed menarche, and menstrual irregularities.[31] The increased injury incidence in female dancers at the lower back, groin, and shoulders could also be linked to the extreme flexibility required at these joints, especially for female dancers,[119-121] and how it is attained. These requirements potentially result in impingement induced instability, compensatory osseous and muscular pathology.[122] Therefore, it has been argued that high levels of range of movement significantly increase overall injury rates.[77,122]

The present study also found that severe (measured by days off) injuries were mainly reported by female AMS dancers from Musical Theatre and Chinese Dance, whereas the AMS group as a whole reported higher injury incidence on the groin ($p<0.05$) than the US group (Table 3). Only a few studies have indicated hip injuries at

a high prevalence and incidence.[4,26,123,124] This high prevalence of groin/hip injuries could be due to students in the affiliation middle dance schools with limited hip range of movement trying to force their external hip rotation to achieve the required extreme flexibility in the hips required from grades 1 to 3 in Musical Theater and Chinese Dance courses (aged 12– 15).

The US group reported higher injury incidence than the AMS group ($p<0.05$). The higher incidence may be linked to their educational background. Chinese dance universities recruited both high-school students with part-time training (3-year) and students from pre-professional secondary schools with full-time training (6-7 year),[45] resulting in group cohorts of very mixed abilities. Stephens et al.[13] suggested that one of contributing factors to injury is increases in training intensity. Compared to the AMS group, the higher reported injury incidence of the US group may be because of the recurrence of old injury; previous studies[8,17,45] had reported reoccurrence of an old injury was the primary issue. Such conditions combined with older age ($p<0.01$) and longer exposure ($p<0.05$) potentially increase the risk of injury. Previous studies also indicated that age[79] and weekly exposure[19] were associated with dance injury.

6.5 Strength and limitations

Based on previous studies' insights[11,19,113] weekly recall surveys should establish a higher quality of data throughout the study period, and the present study established a higher data inclusion criteria than two similar studies,[11,19] which potentially improved the quality of included data.

Within the survey the definitions of injury severity could have misinterpreted by respondents with the use of both "moderate" and "severe" across a number of categories: moderate, moderate to severe, and severe. Definitions were provided but not necessarily read by the respondents.

Out of a total of 450 participants, 240 only partaken in the first semester rather than two semesters. However, this limitation didn't affect the vast majority of the reported results since the authors calculated them weekly rather than over a year. This study also reported an unequal distribution of male and female dance students (20% vs 80%), which may have influenced the sex difference in IP, injury incidence and injury severity.

6.6 Conclusion

To our knowledge, this the first prospective study to determine dance injury incidence and severity in full-time Chinese pre- professional dancers using a weekly remote self-report injury monitoring tool. Injury incidence in Chinese student dancers is higher than that reported in studies on dancers from Western countries. Chinese female dancers are at a higher risk of dance injury compared to male counterparts. Younger dancers reported lower injury incidence than their older colleagues, but higher levels of injury severity, especially in the groin.

7. Study 4: The efficacy of strength and conditioning training on dance injury, physical fitness, and dance performance in Chinese pre-professional dancers: a prospective non-randomized controlled trial

This study has been accepted. Yanan Dang was the primary researcher in the study, and set objectives, designed and delivered intervention training, recruited participants, collected and analysed data, and writing of article.

Dang Y, Niemz M, Koutedakis Y, Chen R and Wyon M (Accepted) The efficacy of strength and conditioning training on dance injury, physical fitness and dance performance in Chinese pre-professional dancers *Eur J Sport Sci*

7.1 Introduction

The previous Chapters (Studies 1 to 3) have reported a higher level of evidence of the injury characteristics in Chinese dancers. As mentioned above in systematic review (Chapter 3) physical fitness training could have a beneficial effect on dance injury. Therefore, this study aimed to examine the effects of strength and conditioning training intervention on dance injury, physical fitness, and dance performance in Chinese pre-professional dancers.

7.2 Methods

7.2.1 Study design and ethics

Study designed as a prospective non-randomized controlled trial and approved by the University of Wolverhampton (11/21/YD/UOW and 07/20/YD2/UOW, Appendices 1a and 4a). We used a snowball approach to recruit volunteers by initially inviting known dance teachers and dance students and then asking them if they would be able to invite more students at the same or other schools to participate. Investigators and participants were located in the United Kingdom and China, respectively and the data collection took place during the COVID-19 travel restrictions. All surveys (physical fitness test and training, dance performance assessment and injury questionnaires) were translated into Chinese by a native Chinese speaker. Before starting these surveys, all student volunteers were asked to sign the consent form (Appendix 4b) using an online tool (https://www.wqx.cn). Students under the age of 18 require parental consent and signature.

Table 7.1 Participants anthropometrics data

	Intervention group (n=67)	Control group (n=22)
Sex (F/M)	F (n=66) /M (n=1)	F (n=22)
Age (years)	16 ± 2.84	19 ± 0.95
Height (cm)	165.3 ± 5.60	167.4 ± 3.36
Body mass (kg)	49.2 ± 5.92	51.3 ± 5.28
BMI (kg/m^2)	18.0 ± 1.39	18.3 ± 1.62

Dance levels	**AMS (n=44)**	**US (n=23)**	**US (n=22)**
Sex (F/M)	F (n=44)	F (n=22) /M (n=1)	F (n=22)
Age (years)	14 ± 1.60	19 ± 1.78	19 ± 0.95
Height (cm)	164.0 ± 5.71	167.9 ± 4.47	167.4 ± 3.36
Body mass (kg)	47.9 ± 6.04	51.7 ± 4.90	51.3 ± 5.28
BMI (kg/m^2)	17.8 ± 1.44	18.3 ± 1.22	18.3 ± 1.62

Please note that AMS means affiliation middle school, US means university students.

7.2.2 Participants

The total of 89 full-time Chinese dance students from five different schools volunteered. At the start of the intervention dancers reported no injury that compromised their ability to fully partake in their respective dance timetable. Sixty-seven students volunteered for the strength and conditioning training intervention; 44 of them were affiliation middle school (AMS) students and 23 university students (US). The control group was comprised by 22 university students (US) (Table 7.1). Sixty-nine participants (47 intervention and 22 controls) had before been a part of a longitudinal injury epidemiology study, and 20 new intervention participants were recruited prior to the start of the present investigation.[114] Participants studied Chinese dance (n=17), ballet (n=4), musical theatre (n=25) and Dancology (n=43).

7.2.3 Physical fitness and dance performance tests

The physical fitness test included 7 tests: plank, calf-raise, side-plank, split-squat, press-up, straight legs raise and vertical jump. Explicit instructions, accompanying videos and online training were provided to the dance teachers who supervised the data collection. The students wrote down on the assessment sheet how long (seconds) and how often (times) they could perform these movements. Additionally, vertical jump height (cm) in ballet first position was evaluated using "My Jump 2" application (Appendix 4c).

Dance performance was evaluated using a previously published dance performance assessment tool[59] by the students' own dance teachers. The 10-item tool used a 1-10 Likert scale and focused on coordination, control of movement, spatial awareness, accuracy of movement, skill level (virtuosity), timing and rhythmical accuracy, response to phrasing and dynamics, expression and interpretation, communication/projection, and "X-factor" (Appendix 4d).

7.2.4 Injury monitoring

Participants were instructed to self-report injuries on a weekly basis during the monitoring period using a remote dance injury monitoring tool.[113] Its questionnaire distribution method, informed consents design, and reminder sending time were reported in Study 2.[113] The present study used an inclusive injury definition that was categorized into four levels (Introduction), and new and old injuries were defined in Study 2.[45,113,114]

7.2.5 Intervention design

Due to the fact that affiliation middle school students (AMS, n=44) and university students (US, n=23) had varying academic term time, they completed a 12 (AMS, n=44)

or 11 (US, n=5)/10 (US, n=18) weeks of training intervention, respectively. The strength and conditioning intervention focused on improving the dancers' whole-body fitness (strength, endurance and balance) and comprised two sessions per week of between 40-60 minutes. The training included 4 different circuits; there were 9 exercises in each circuit, each exercise was carried out for 50 seconds with 10 seconds to change station. The exercises were combined into 3-exercise groups that moved from the upper body to the core and finally lower body; after every 3-exercise group was completed, the dancers performed 1-minute of skipping to keep the heart rate at a certain level (Appendix 4e). Each circuit was repeated three times per session, apart from the first session of each circuit which was repeated twice per session, to allow participants to familiarize the techniques of each movement (Appendix 4f).

Dance teachers underwent two online training sessions before the start of each circuit. Dance teachers then taught their own students and supervised students' exercises in their dance studio. A simple set of equipment was required for each student that included a Yoga Mat and resistance band. The intervention took place between September to December 2021 and the pre and post physical fitness and dance performance tests occurred in the week before and immediately following the intervention. The study took approximately 14 weeks to complete.

7.2.6 Inclusion - exclusion criteria

Participants were included if they completed the entire intervention, the pre and post tests and completed 90% of the weekly injury surveys. Participants were excluded if they missed three consecutive weeks of the injury survey.[114] All participants complied with the current requirements.

7.2.7 Data analyses

A dance injury data processing software was developed which created a unique

identification code (UIC) for each individual based on their account name, student number, and school name. Only the leading author had access to both the individual's name and contact details, while the rest of the research team could only see the participants' UIC.

All data were analysed using descriptive statistical analysis in Excel and SPSS version 28 (SPSS, Inc., Chicago, IL, USA). A multivariate analysis of variance and one-way ANOVA were used to compare the difference in physical fitness and dance performance pre and post-intervention. Injury data were initially analysed between the intervention and control groups in the first semester (September to December, 13 weeks) 2021; the intervention groups' injury data were further analysed in comparison to their own data collected during the same period of the previous year (2020 vs 2021). These data were analysed using one-way ANOVA, independent-samples t-test, paired-samples t-test, Mann-Whitney U test and Wilcoxon signed ranks test. Significance was set at $p \leq 0.05$.

7.3 Results

A total of 90 Chinese full-time dance students initially volunteered for this study, with one dance student dropping out in the middle of the study, with 89 participants' (F=88, M=1) data included in the analysis. (Table 7.1).

7.3.1 Physical fitness and Dance performance

After the intervention training, the overall physical fitness level (10 items) of the 67 pre-professional dancers improved significantly ($p<0.001$) with specific tests demonstrating substantial improvements: calf raise (both sides), split squat (right side), press-up and straight legs raise and vertical jump. In sub-groups, more improvements were reported in the split squat on the left leg ($p<0.05$) of the US group and the plank test ($p<0.01$) and side plank on the right side ($p<0.05$) of the AMS group. (Table 7.2).

Table 7.2 Physical fitness compared between pre- and post-intervention

Tests	Full cohort (n=67)		US sub-group (n=23)		AMS sub-group (n=44)	
	Pre	Post	Pre	Post	Pre	Post
Plank (sec.)	109 ± 44.97	134 ± 62.07	129 ± 58.67	117 ± 56.75	99 ± 32.03	143 ± 63.52‡
Calf raise Left leg (reps)	21 ± 6.95	30 ± 9.86‡	21 ± 7.76	28 ± 8.90‡	22 ± 6.51	30 ± 10.35‡
Calf raise Right leg (reps)	22 ± 6.24	30 ± 10.74‡	21 ± 6.58	27 ± 10.65†	23 ± 6.02	31 ± 10.70‡
Side-plank Left (sec.)	77 ± 23.00	81 ± 26.36	74 ± 18.21	73 ± 28.43	78 ± 25.24	85 ± 24.64
Side-plank Right (sec.)	75 ± 30.27	81 ± 24.25	68 ± 18.33	75 ± 17.54	78 ± 34.60	84 ± 26.73†
Split squat Left leg (reps)	35 ± 14.84‡	38 ± 15.56	35 ± 15.69‡	44 ± 16.78†	34 ± 14.56	36 ± 14.22
Split squat Right leg (reps)	32 ± 14.89‡	38 ± 15.02‡	29 ± 15.79‡	44 ± 16.85‡	34 ± 14.35	36 ± 13.28
Press-up (reps)	13 ± 8.84	23 ± 8.93‡	15 ± 6.58	23 ± 8.81‡	12 ± 9.79	23 ± 9.09‡
Straight legs raise (reps)	28 ± 12.48	37 ± 12.36‡	35 ± 13.65	44 ± 12.71†	25 ± 10.19	34 ± 10.67‡
Vertical jump (cm)	21.2 ± 4.59	24.5 ± 3.54‡	23.5 ± 4.97	25.9 ± 2.59†	20.1 ± 3.96	23.7 ± 3.74‡

Please note that AMS means affiliation middle school, US means university students; † means $p<0.05$, ‡ means $p<0.01$; † and ‡ in the column of "post" mean the significances of the comparison between pre- and post-intervention, ‡ in the column of "pre" means the significances of the comparison between left and right sides.

Significant differences between the left and right sides in split squats ($p<0.01$) were noted pre-intervention but no difference post-intervention ($p>0.05$) for the whole cohort (n=67) and the US group (n=23) (Table 7.2).

There was no statistical improvement in dance performance ($p>0.05$) after the intervention from the dance teacher assessments of dance class (Appendix 4g).

7.3.2 Injury incidence

The intervention (n=67) and non-intervention (n=22) groups showed no difference in weekly injury prevalence ($p>0.05$). However, during the intervention period, the former group reported longer dance exposure ($p<0.05$) and higher injury incidence ($p<0.05$) than the latter. For the US group during the same period, there was no difference between the intervention group (n=23) and the control group (n=22) in dance exposure ($p>0.05$), injury incidence ($p>0.05$) and injury prevalence ($p>0.05$).

There were 47 students in the intervention group that had provided injury data for the same period of the previous year.[114] No changes ($p>0.05$) in dance exposure (hours) for this intervention subgroup in two different years ($p>0.05$) were found. Comparisons of the self-reported injury data for this group between 2021 (intervention) and 2020 (control) indicated self-reported lower weekly injury prevalence percentages (28% vs 15%, $p<0.001$) and injury incidence (8.09 vs 5.16 injuries/1000hrs, $p<0.05$) during intervention period compared with their injury during the same period in 2020. The US and AMS groups all reported lower weekly injury prevalence (US: 31% vs 12%, $p<0.001$; AMS: 30% vs 18%, $p<0.001$) during the intervention period than the same period in 2020, but no statistical decrease in injury incidence ($p>0.05$) (Table 7.3).

7.4 Discussion

It has been previously stated that the strength of studies on aspects related to injuries are limited by sample size and the level of evidence.[50,55] Furthermore, most of the relevant studies were conducted using western participants. Therefore, the aim of

Table 7.3 Injury prevalence and incidence compared between pre- and post-intervention

September to December 2021: Intervention group vs Control group

	Full Cohort		US sub-group	
	Intervention (n=67)	Control (n=22)	Intervention (n=23)	Control (n=22)
Dance exposure (hrs)	234 ± 76.88†	184 ± 80.08†	228 ± 90.99	184 ± 80.08
Injury Prevalence (%)	17% ± 4.83	5% ± 4.89	12% ± 5.34	5% ± 4.89
Injuries/1000hrs	5.08 ± 7.70†	1.66 ± 4.21†	4.30 ± 8.42	1.66 ± 4.21

September to December 2020 vs September to December 2021

	Full Cohort (n=47)		US sub-group (n=23)		AMS sub-group (n=24)	
	2021 (intervention)	2020 (control)	2021 (intervention)	2020 (control)	2021 (intervention)	2020 (control)
Dance exposure (hrs)	243 ± 81.80	258 ± 141.35	228 ± 90.99	231 ± 126.54	257 ± 71.07	284 ± 152.44
Injury Prevalence (%)	15 ± 38.77‡	28 ± 8.48‡	12 ± 5.34‡	31 ± 15.87‡	18 ± 5.93‡	30 ± 10.50‡
Injuries/1000hrs	5.16 ± 8.54†	8.09 ± 9.69†	4.30 ± 8.42	8.12 ± 10.84	5.98 ± 8.74	8.07 ± 8.68

Please note that AMS means affiliation middle school, US means university students; † means $p<0.05$, ‡ means $p<0.01$.

the current work was to either reinforce or attenuate existing information by examining the effects of a strength and conditioning training intervention on dance injury, physical fitness and dance performance in Chinese pre-professional dancers. Our results support the notion that improving physical fitness levels are associated with decreasing dance injury.[55,57,64,75,77,78] This study applied an inclusive injury definition to examine the effectiveness of strength and conditioning training on dance injuries across the dance genres of Chinese Dance, Ballet, Musical Theatre and Dancology.[45]

The lower injury incidence for the intervention group is consistent with previous studies that used a similar physical fitness training load,[50,55] frequency (2-3-session/week),[51,53,54,68,86] and session duration (~60-min).[51,54,68] However, the intervention period in the current study (10-12 weeks) was longer than the equivalent of previous studies that ranged between 4-10 weeks.[50,51,53,68,86] Also compared to most previous physical fitness intervention studies,[50,53,55,67,68,86] we recruited a larger sample size (89 vs ~30)[50] and employed a valid monitoring tool[113] for tracking dance injuries on a weekly basis, as opposed to just one-off questionnaires[53,54,86] or visual analogue scales,[52-54,68] thereby providing a higher data quality reporting[72] and a stronger foundation for recommendations.[50] Given that dance exposure (hours) has been previously shown to be associated with dance injuries,[19,33,125] the use of a concurrent control group and previous year's data from the intervention group helped us to control the variation in dance exposure across the different training institutions. The participants self-reported no changes in their dance exposure (hours) and therefore the observed decrease in dance injury incidence further confirms the beneficial effect of strength and conditioning training on dance injuries.

The present study also reported improvements in dancers' strength and endurance on their lower legs (calf raise, split squat, and vertical jump), upper body (press-up), and core (straight legs raise), especially for university students' lower leg strength (split squat) and core endurance (plank and side-plank) in adolescent dance

students, in line with published data.[52,55,66] Furthermore, analysis of the pre-intervention physical fitness tests revealed a bilateral imbalance in the lower extremity strength (split squat) in the participants, particularly university students. This may be due to their previous dance training experience, since over half of the university students (18 out of 23) had only been involved in part-time dance training prior to enrolling in university. The present strength and conditioning training intervention improved the observed bilateral imbalance.

All above improvements in physical fitness components are supposed to lead dancers to better performances.[50,80] However, and contrary to previous findings,[50,59,63,65,80] the present study revealed no statistical improvement in dance performance post-intervention. Possible explanations could be the different methods of dance performance assessment and physical fitness training intervention. For instance, previous studies blindly marked the dance performance,[59,80] but in the present study the evaluators weren't blinded as they were the participants' dance teachers. We were forced to follow this approach due to COVID-19 restrictions. This could result in teachers not visibly noticing participants progress because they were teaching them on a daily basis. Moreover, the present study did not duplicate previous studies where a dedicated set performance piece[59] was carried out before and after the intervention as the present study used a basic dance class. The physical fitness training intervention could have been less effective, despite the observed significant improvements, as it was delivered by dance teachers who had received just two online training sessions.[42]

Currently, most dance institutions do not have dedicated physical fitness training, beyond somatic training, that is scheduled into their curriculum[126] and there is limited evidence that somatic training has a direct impact on dance movement.[127] Without this integration, additional training load would increase dancers' fatigue levels potentially increasing the risk of injury.[45,77,128,129] Therefore, the present results suggest that dance schools should incorporate specific strength and conditioning training

classes in their curriculum in order to reduce the risk of dance injuries.

It is reasonable to assume that the present results may have been influenced by methodological limitations. For example, the participants in the intervention group originated from two different dance levels (the AMS and the US), but the control group only emanated from the US group; and these two groups were not randomly assigned. Moreover, the intervention group testified longer dance exposure than the control group ($p<0.05$), which further increased the risk of injury, as dance hours is a key factor for such injuries.[19,33,125] Finally, it should be considered that the current research was based on remote testing and training methods, due to COVID-19 restrictions, with the associated danger of errors during the stage of data collection.

7.5 Conclusions

Strength and conditioning training improves physical fitness levels and decreases the risk of injury in pre-professional dancers without detrimentally affecting dance performance. These results are more robust than those from previous studies because of the larger sample size, longer length of training intervention, and the weekly dance injury monitoring tool. Future studies need a higher level of evidence (a randomized controlled trial) to fortify the positive effects of strength and conditioning training on dance injuries.

8. Summary discussion

8.1 Summary of the main findings

This chapter will summarise major findings, demonstrate strengths and limitations with a discussion of the practical implications of the results, and make recommendations for future studies.

This Thesis aimed to investigate the effect of physical fitness training on dance injury in Chinese full-time pre-professional dancers. Initially, a systematic review was conducted to evaluate the status of previous research and then derived a series of subsequent studies. These four consecutive studies were to investigate and compare injury prevalence, causes, and risk factors before and after the COVID-19 lockdown (Study 1); to develop a dance injury monitoring tool and examine its efficacy of weekly reporting and respondent compliance (Study 2); to determine injury incidence and injury severity using the injury monitoring tool (Study 3); to examine the efficacy of strength and conditioning training on dance injury, physical fitness, and dance performance (Study 4).

This was the first systematic review to review the relationship between physical fitness training and dance injury. The evidence revealed that physical fitness training could positively affect dance injury but is limited by the study methodologies, for instance, the heterogeneity of the studies, the low sample sizes, the weak methodological designs and reporting, and the evidence is based on few or single studies.

Study 1 is the first peer-review study that investigated and compared injury prevalence, causes, and risk factors before and after the COVID-19 lockdown. The results, from 2086 full-time Chinese pre-professional dancers, showed respondents self-reported that although injury prevalence dropped significantly from 39.6% (before

the lockdown) to 16.5% (during the lockdown), the main dance injury characteristics (main sites, tissue, severity, and causes) remained the same.

Study 2 developed a unique weekly online dance injury monitoring tool and was the first to examine the efficacy of a weekly reporting and respondent compliance. Although the present study reported a high drop rate (70.1%), it recruited more respondents and was more open to 16 different institutions. The present survey suggests that future studies need to establish a higher quality of data inclusion criteria to improve data quality, and the researchers would need to weigh reduced completion rates (<100%) against data efficacy to achieve generalizability.

Study 3 is the largest study to determined dance injury incidence and severity in full-time pre-professional dancers. Using an injury monitoring tool developed in Study 2, injury prevalence was reported as 64.9%, and injury incidence was 5.51 injuries per 1000 hours. The injury incidence found in this study is higher than most previous data sets. Female dancers are at a higher risk of injury and reported higher levels of injury severity than male dancers, especially for the female adolescent group.

Study 4 examined the efficacy of strength and conditioning training on dance injury, physical fitness, and dance performance. It is concluded that strength and conditioning training improved physical fitness levels and decreased the risk of injury in pre-professional dancers without detrimentally affecting dance performance.

8.2 Injury trends throughout the thesis project

The injury trend through a 3-year thesis project was dynamic. In the beginning of this programme of research, dancers met an unexpected COVID-19, as such study 1 found that the injury prevalence dropped significantly during the lockdown compared to pre-COVID-19.[45] On the contrary, adolescent dancers had an increased injury risk during the pandemic lockdown possibly due to their reduced feelings of fatigue like the university dancers pre-COVID-19, and they also reported a higher percentage of

accidents.[45] These results could also possibly be due to a specific training condition in China with these AMS students. When dancing at home in 2020, adult dancers did not practice under their parent's supervision, but adolescent dancers did. Most adolescents' parents were skilled in dance training as they usually accompanied their children doing training during the whole process. However, they were not professional dance teachers, and young dancers may not be good at copying techniques in unfamiliar environments (smaller spaces, different floor surfaces, and unstable internet connection).[42,104] Continue to Study 3,[114] from 2020 to 2021, which reported higher injury prevalence in the first three weeks of the first term. A sudden increase in training load after returning from a long period of the summer holiday (2 months) may be linked to this holiday.[45,99]

In Study 4, injury incidence and prevalence were reduced after delivering strength and conditioning training. These injuries were compared in the first term (including the first three weeks in each term) in two different academic years in 2020 and 2021. Over time, four studies were gradually affected less by the COVID-19 lockdown, so Study 4 should be seen as less affected by the COVID-19 lockdown than Study 3.[114] Study 1 revealed that the injury prevalence dropped significantly during the COVID-19 lockdown.[45] According to this result, the injury prevalence in Study 4 should be higher than the data recorded in Study 3,[114] but the intervention group (Study 4) reported lower injury prevalence, further confirming the positive effect of strength and conditioning training on dance injury.

8.3 Strengths

This thesis used Chinese full-time pre-professional dancers as participants whose injury data were rarely investigated and published in English as peer-reviewed publications,[17] contributing to the body of knowledge in dance medicine and science. The recruited participant numbers for this thesis' studies were the largest sample size compared with previous studies[17]: Study 1, 2086 dancers; Study 2, 756 dancers; Study 3, 450 dancers; and Study 4, 89 dancers. The participants in studies 2-4 came from the participants recruited in Study 1; this improves the credibility and reliability of the results.[50]

Moreover, the present thesis employed published research methodologies,[90] making it possible to compare dance injuries between Chinese dancers and dancers from Western countries.[8,17,97,98]

Based on the findings of the systematic review (Chapter 2), the previous study methodologies limited the evidence.[55] Study 2 to Study 4 developed and employed a valid dance injury monitoring tool to track dance injury, which drove the study design from retrospective to prospective.[113] Study 3 and Study 4 established stricter inclusion and exclusion criteria than similar injury surveillance studies,[78] reporting more accurate and reliable injury data at a higher level of evidence.[16]

This thesis reported detailed intervention information in response to one of the findings from the systematic review that there is a lack of intervention details.[55] In study 4, injury definition, sample size, participants' anthropometric information (gender, age, height, weight, BMI, dance genres) and dance training background, the condition of dancers before starting intervention training, study design, assessment tools, exercises design (purpose, time, frequency, training intensity, method) and delivery method were included. This detail allows the study to be replicated, and the results can be verified again and compared.[8,17,97,98]

Over the past decades, different dance injury research, dance institutions, scientists, and international associations have been seeking effective strategies to decrease the risk of dance injuries. The results from this thesis revealed that strength and conditioning training decreased injury incidence for dancers, and the data were based on a relatively high-quality study with a higher level of evidence and a large sample size. The results from this thesis add to the body of knowledge available to the dance community to better understand the benefits of supplemental strength and conditioning training on dance injury.

8.4 Limitations

It is reasonable to assume that there are limitations. Studies were adjusted from in-person to online because of the unexpected COVID-19 lockdown, potentially increasing the risk to data collection, participant adherence and intervention efficacy (learning correct movement techniques in Study 4).

Although Study 4 evidenced the positive effect of strength and conditioning training on dance injury, it should not be ignored that during long-term recall surveys, it is possible for students to become tired of reporting their injuries. Nevertheless, we designed the questionnaire's questions to appear or be hidden depending on their choice to decrease the pressure of frequently filling out questionnaires.

Study 4 was not designed as a randomized control trial. In practice, it is hard to conduct a randomized control trial because our participants were from three different dance schools, and each school's participants came from the same school and in the same class. It was not possible to randomly split them into two different groups (intervention vs control groups). Moreover, Study 4 reported no statistical improvements in dance performance that may not only be linked to different assessment methods (Study 4) but also inappropriate assessment content. The present strength and conditioning training aimed at improving dance performance, while the present study tested a regular dance class. The systematic review agreed that dance classes have lower cardiorespiratory demand than dance performances.[55,130]

8.5 Future research

This thesis makes recommendations for future studies in a few aspects.

Firstly, it is reasonable to encourage more studies to focus on decreasing the risk of dance injury, recruiting a larger sample size, designing research with a high level of evidence (RCTs), and reporting detailed information on research methods. In addition, future studies are suggested to report intervention studies with a standard

intervention protocol to allow others to repeat the experiment and verify the results.

Secondly, taking this thesis into account, only a few studies employed dance injury monitoring tools to record dance injuries; the thesis recommends that more Chinese dance institutions incorporate injury monitoring into their systems to help understand and keep track of the latest condition of dancers.

Thirdly, dancers trust physical therapists or trainers who understand dance training.[131] Future Chinese studies are suggested to open additional online access to applying strength and conditioning training in dance practices for professionals (dancers and dance educators). Although the COVID-19 lockdown promoted intervention training (Study 4) into an online delivery that may increase the risk of data collection, it did a good way of recruiting a larger sample size and delivering intervention training to participants across countries. It is also a channel that is conducive to spreading knowledge of strength and conditioning training aimed at preventing dance injuries.

Fourth, the thesis suggests future intervention studies aiming at improving dancers' whole-body fitness. And we further recommend future studies choose appropriate assessment content and methods, same strength and cardiorespiratory demand as intervention training and test dance performance blindly, to test the efficacy of strength and conditioning training on dance performance.

9. Conclusions

The present Thesis examined the effectiveness of physical fitness training on dance injury. Study 1 indicated that injury prevalence dropped significantly during the COVID-19 era, but the main injury causes and risk factors remained the same. Study 2 showed the efficacy of weekly reporting and reported a low level of respondent compliance. Evidence revealed that there are significant differences in dance injury incidence and injury severity for Chinese full-time pre-professional dancers in Study 3, and Study 4 evidenced that strength and conditioning training positively affect dance injury and physical fitness with no detrimental effects on dance performance.

This Thesis reinforces the effectiveness of physical fitness training on dance injury with a higher level of evidence using a novel dance injury monitoring tool. The research has contributed to moving one step closer to reducing and preventing dance injuries and enriching the diversity of participants in dance injury studies.

10. My development

In the last four years, I gradually developed my research skills, learned complex statistical analyses, and gained practical experience as a PhD student. In fact, I completed two systematic reviews. Although this thesis used the second one <The Efficacy of Physical Fitness Training on Dance Injury>, the first one, <The Rehabilitation for Injured Dancers> helped me win the Student Research Fund at the International Association of Dance Medicine and Science 30th Annual Conference. After its completion, I was already aware that it needed to be changed. Firstly, the inclusion criteria of the first systematic review were wider than I wanted, which resulted in including over 100 studies. Secondly, the majority of them could not be applied in my research area. However, these steps helped me to identify the differences between my two systematic reviews, for instance, inclusive injury definition and medical attention/time-loss definitions, one-off questionnaire (retrospective study) and injury monitoring (prospective study), surgery rehabilitation and physical fitness training.

When recruiting participants for my injury monitoring survey and practical strength and conditioning training survey, I felt dancers and their dance teachers' were eager to gain some dance-science knowledge, as 2086 and 756 dancers engaged in Study 1 and 2, respectively. However, I also felt their rejection of experimental research that lasted 14 weeks, which could be linked to their heavy training and busy time schedule. In addition, it was hard to randomly split them into two groups as they came for the intervention training, and most of them came from the same class they needed to receive the same training. We did have a control group from different schools, but dance exposure (hrs) and other variables could not be controlled. Therefore, I hope future dance institutions can add strength and conditioning training into their curriculum to improve the possibility of recruiting more participants to design the study as a randomized controlled trial.

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12. Appendices

a Assessment Scores of the Strength of the Evidence for a Conclusion

	Studies	Design	Evidence level	Quality	Consistency	Quantity	Clinical Impact	Generalizability	Score- Median (mean, SD)
1	Long et al., 2021	A Mixed-Methods Quasi-Experimental Study	3b	3	2	4	3	3	3 (3±0.71)
2	Vera et al., 2020	A Randomized controlled trail study	1	4	3	4	4	4	4 (3.8±0.45)
3	Viktória et al., 2016	A non-randomized longitudinal study	3a	3	3	2	2	4	3 (2.8±0.84)
4	Welsh et al., 1998	Poor quality cohort study	4	4	4	4	3	4	4 (3.8±0.45)
5	Kline et al., 2013	Poor quality cohort study	4	3	3	4	3	3	3 (3.2±0.45)
6	Roussel et al., 2014	A randomized controlled trial study	2b	2	3	2	3	4	3 (2.8±0.84)
7	KiM et al., 2017	A prospective randomized clinical trial	2b	3	3	3	3	3	3 (3±0)
8	Mistiaen et al, 2012	An un-controlled trail	2b	3	3	2	4	3	3 (3±0.71)
9	Allen et al., 2013	A 3-year Prospective cohort study	2a	2	1	1	2	2	2 (1.6±0.55)

10	Chong and Chen, 2011	A cohort study	3a	2	2	3	3	3	3 (2.6±0.55)

1=Good, 2=Fair, 3=Limited, 4=Expert Opinion Only, 5=Grade Not Assignable.

b Assessment Scores of the Checklist for assessing the quality of quantitative studies

Criteria (1-14)		Long et al., 2021	Vera et al., 2020	Long et al., 2021	Welsh et al., 1998	Kline et al., 2013	Roussel et al., 2014	KiM et al., 2017	Mistiaen et al., 2012	Allen et al., 2013	Chong and Chen, 2011
1	Question / objective sufficiently described?	2	1	1	1	2	2	2	1	2	1
2	Study design evident and appropriate?	1	2	1	1	1	2	2	1	2	1
3	Method of subject/comparison group selection or source of information/input variables described and appropriate?	2	2	2	0	2	1	2	1	1	1
4	Subject (and comparison group, if applicable) characteristics sufficiently described?	2	1	1	1	1	2	1	0	1	1
5	If interventional and random allocation was possible, was it described?	N/A	2	N/A	N/A	N/A	1	2	N/A	N/A	N/A
6	If interventional and blinding of investigators was possible, was it reported?	N/A	1	N/A	N/A	N/A	0	0	N/A	N/A	N/A
7	If interventional and blinding of subjects was possible, was it reported?	N/A	1	N/A	N/A	N/A	0	0	N/A	N/A	N/A
8	Outcome and (if applicable) exposure measure(s) well defined	1	2	1	1	1	2	1	2	1	1

	and robust to measurement / misclassification bias? means of assessment reported?										
9	Sample size appropriate?	0	0	2	0	0	1	0	1	2	1
10	Analytic methods described/justified and appropriate?	2	2	2	0	0	2	2	2	2	1
11	Some estimate of variance is reported for the main results?	0	0	0	0	0	0	1	1	1	0
12	Controlled for confounding?	0	1	0	0	0	0	0	0	0	0
13	Results reported in sufficient detail?	1	0	1	0	0	2	1	2	2	1
14	Conclusions supported by the results?	0	0	1	1	1	1	1	1	1	0
Total score obtained		11	15	12	5	8	16	15	12	15	8
Total possible score		22	28	22	22	22	28	28	22	22	22
Summary score (%)		50	53.57	54.55	22.73	36.36	57.14	53.57	54.55	68.18	36.36

“yes” = 2, “partial” = 1, “no” = 0.

c Intervention Location, Equipment and Supervision

	Studies	Location	Form	Equipments
1	Long et al., 2021	Studio	Physical therapist, dance liaison (with handout outlining)	TheraBand, Bar, Bench
2	Vera et al., 2020	At class, rehearsal, and performance space.	Unsupervised, Booklet, graphic, video	Resistance band
3	Viktória et al., 2016	NR	NR	NR
4	Welsh et al., 1998	Clinic located 2 miles from campus	Supervised daily by physician, physical therapist and fitness trainer	The MedX corporation, Several Nautilus machines
5	Kline et al., 2013	Home exercise, or maybe clinic	Unsupervised and supervised by physician and physical therapist	The dynamic sling setup, floor mat
6	Roussel et al., 2014	NR	Supervised by a certified physiotherapist and a dance teacher.	Electronically braked bicycle ergometer, bicycles, steps, rowing machines, unstable platforms, elastic bands
7	KiM et al., 2017	Maybe dance studio and clinic	Under the supervision of a skilled physical therapist (and assistants).	Electronic inclinometer, medical bed, hand-held dynamometer, TheraBand
8	Mistiaen et al., 2012	NR	Supervised by physiotherapists and a dance teacher, leaflet	Ergometer, electronically braked bicycle ergometer, Bicycles, steps, stadiometer, rowing machines, resistance devices
9	Allen et al, 2013	Pool and studios	NR	Pilates reformer
10	Chong and Chen, 2011	Rehabilitation laboratory	NR	Dynamic and static balance training device, power bike, joint protractor, medical bed, bench, wire, tape measure, rubber band

NR = Not Reported

1a Ethical approval letter

Dr Alexandra Hopkins RN PhD MSc MBA RNT RCNT DANS
Dean of the Faculty of Education Health and Wellbeing

University of Wolverhampton
Walsall Campus
Gorway Road
Walsall
WS1 3BD
United Kingdom

Telephone Codes
UK: 01902 Abroad: +44 1902

Switchboard: 321000

Internet: www.wlv.ac.uk

Date 27th July 2020

Yanan Dang
University of Wolverhampton
FEHW

Dear Yanan

Re: "Injury incidence in Chinese Dancers **"**

The Faculty Ethics Panel (Sports) has considered and reviewed your submission**.**

On review your Research Proposal was passed and the Panel believes that the ethical issues inherent in your study have been adequately considered and addressed. Therefore the Panel is giving you full ethical approval for your study (Code 1 – Approved –Unique code: (07/20/YD2/UOW).

We would like to wish you every success with the project.

Yours sincerely

[redacted]

Professor Matt Wyon
Chair – Ethics Panel

1b Questionnaire COVID-19 (English version)

Informed consent:

Please read the following statements carefully. At the end you will be able to click whether you accept this statement and are happy for your answers to be used for research purposes.

- This first survey focuses on injuries that you have had whilst dancing over the last 12 months. You will also be asked to complete personal information that included your age, height and weight, where you train, how many hours you dance a day/week. It should take only 15 minutes to complete.

- I know my information will be totally confidential and I will only be recognised by a unique Wechat Account and student number (next page).

- I know that I am not obliged to complete the survey and that I can stop the survey at any point and for any reason.

- The survey results are confidential and will only be communicated to others within the research team.

1. Are you over 18 years old? Yes_____ No_____

2. If yes. Please click whether you accept these statements?

   a) Yes_____ (nest page) No_____

3. If no. Please note that these statements require the consent of you and your parents. Please click whether you all accept these statements? (If you all agree, please click "yes", if one of you or you all disagree please click "no".)

   a) Yes_____ (nest page) No_____

Identifier Code and Personal Information

1. Are you currently? (single choice)

   a Affiliation middle school students

b University dance students

2. Gender_____； Ages_____; Weight_____(kg); Height_____(cm).

3. What is your school's name? (single choice)

a Beijing Dance Academy
b Tianjin Sports Academy
c Shanghai Movie Art Academy
d Sichuan Music Academy
e Wuhan Sports Academy
f Shenyang Music Academy
g Hebeiminzu Normal Academy
h Shanghai Theatre Academy
i Nanjing Art Academy
j Yanshan University
k Others, please specify_____

4. What the age when you entered full-time（university） training? ____ （if you were High school dance students）

What the age when you entered full-time training? ____ （if you were Affiliation middle school students）

5. What is your dance background before your enrolled your university?

a High school dance students
b Affiliation middle school students

6. What grade are you currently in? (single choice)

a 1st Affiliation middle school
b 2nd Affiliation middle school
c 3rd Affiliation middle school
d 4th Affiliation middle school
e 5th Affiliation middle school
f 6th Affiliation middle school
g 7th Affiliation middle school
h 1st Year University
i 2nd Year university
j 3rd Year university
k 4th Year University

l Other, please specify_____

7. What is your main dance genre? (single)

a Dancology
b Ballet
c Contemporary Dance/ Contemporary Dance choreography
d Chinese folk Dance
e Chinese classical dance
f Chinese Dance
g Sports Dance
h Other, please specify_____

8. How many hours on average do you do a week of before your school shut down? (fill in every option, if you don't do one/some of them, just choice "0" option.)

a Dance Classes number of hours_____
b Rehearsal number of hours _____
c Performing number of hours _____
d Body conditioning number of hours _____

How many hours on average do you do a week in the period if COVID-19? (fill in every option, if you don't do one/some of them, just choice "0" option.)

a Dance Classes number of hours_____
b Rehearsal number of hours _____
c Performing number of hours _____
d Body conditioning number of hours _____

9. How many hours of sleep a night on average do you…?

a Before shut down ____
b After shut down ____

10. How fatigue did you feel? (1-10, 1 means no fatigue, 10 means very fatigue）

a Before shut down ____
b After shut down ____

11. Do you warm up…

Yes __ No__

11.1 If yes, for how long (minuste)?

		0	1-5	6-10	11-15	around 20	30 and more
a	Before class	___	___	___	____	____	___
b	Before rehearsal	___	___	___	____	___	___
c	Before performance	___	___	____	____	____	___

12. Do you cool down…

    Yes __ No__

12.1 If yes, for how long? (minutes)

		0	1- 5	6-10	11-15	around 20.	30 and more
a	After class	___	___	___	____	___	___
b	After rehearsal	___	___	___	____	___	___
c	After performance.	___	___	___	____	___	___

13. Is time set aside in your school to Warm up? Yes ____ no ____ (single choice)

    Is time set aside in your school to Cool down? Yes ____no ____ (single choice)

Injury Information

Dance Injury is defined as a physical problem that happened whilst dancing, which represents/shows pain or discomfort and results in modified participation, dysfunction, reduced range of movement and even stopping you immediately in any dance activity

14. In the last 12 months (include long-term injury over last 12 months but affected you in last 12 months), did you have dance injury(ies)? (single choice)

    Yes_____ no _____

15. If you did have injuries in the last 12 months, where were the sites of injury? (multiple choice)

    a Upper and lower arms
    b Hands
    c Elbow joints

d Wrist
e Shoulders
f Neck
g Upper back
h Lower back
i Ribs
j Pelvis/hips
k Hip joints/groin
l Thighs
m Knees
n Lower legs
o Ankles (including Achilles's tendon)
p Feet

16. Have you had any of the following injuries in training, rehearsal and/or performance in the last 12 months? (multiple choice)

a Muscle
b Bone
c joint/ligament
d tendon
e other, please define _____

17. How severity was of your injury? (multiple choice)

a Minor (feel pain/uncomfortable, but I can still dance)
b Moderate (I have to adapt my movement or can't do certain movements)
c Moderate to Severe (break off but less than 1 day)
d Severe (can't dance for at least 1 day or more than 1 day)
If severe, how many days can take those ones? ___days (single choice)

18. What do you think was the cause of these injuries in the last 12 months? (multip)

a) Fatigue
b) Limited/bad flexibility
c) Unsuitable floor
d) Cold environment
e) Insufficient/improper warm up
f) Insufficient/ improper cool down
g) New/difficult choreography
h) Different repertory
i) Repetitive movement

j) Partnering work
k) Incorrect technique/training
l) Ignoring early warning signs
m) Lack the sense of self-protection
n) Recurrence of old injury
o) Inadequate diet/hydration
p) Set/props
q) Costume/shoes
r) Improper Rehearsal schedule
s) Accident
t) Other, please explain briefly_____

19. What type of professional help did you initially have for your injuries? (multiple choice)

a) Physiotherapist
b) general practitioner (doctor in China)
c) osteopath
d) chiropractor
e) Masseur
f) Acupuncturist
g) Dietician
h) Psychologist
i) Pilates
j) Didn't find any professional help
k) Other, please specify_____

20. What do you do if you suspect an injury? (multiple choice)

a Seek professional medical treatment
b Tell someone else
c Take own preventative steps
d Take pain killers
e Continue to dance, but carefully
f Ignore it
g Hide it
h Other, please specify_____

21. Who has the most influence in guiding your return to activity? (multiple choice)

a Doctor (GP)/Therapist
b Teacher

c Yourself
d Other, please specify_____

22. Whether you had your class online in the period of COVID-19? Yes /no (single.)

23. If yes, how long already? (single choice)

a 1 months
b 2 months
c 3 months
d 4 months
e 5 months
f 6 months
g Over 6 months

24. Where you dancing on?

a Household wooden floor
b Ceramic floor
c Carpet
d Yoga mat
e Dance floor (rubber)
f Other, please specify_____

25. Whether your injury happened in this period time（2020-02---2020-08）? (link with injured dancers)? (single choice)

Yes _ no_

26. Which sites?

a Upper and lower arms _____
b Hands_____
c Elbow joints_____
d Wrist_____
e Shoulders_____
f Neck_____
g Upper back_____
h Lower back_____
i Ribs_____
j Pelvis/hips _____
k Hip joints/groin_____

l Thighs _____
m Knees_____
n Lower legs_____
o Ankles (Achilles's tendon) _____
p Feet_____

27. Have you had any of the following injuries? (multiple choice)

a Muscle
b Bone
c Joint/ligament
d Tendon
e Other, please define _____

28. How severity was of your injury? (multiple choice)

a Minor (feel pain/uncomfortable, but I can still dance)
b Moderate (I have to adapt my movement or can't do certain movements)
c Moderate to Severe (break off but less than 1 day)
d Severe (can't dance for at least 1 day or more than 1 day)
If severe, how many days can take those ones? ___days (single choice)

29. What do you think was the cause of these injuries in this period time? (multip)

a Fatigue
b Limited/bad flexibility
c Unsuitable floor
d Cold environment
e Insufficient/improper warm up
f Insufficient/ improper cool down
g New/difficult choreography
h Different repertory
i Repetitive movement
j Partnering work
k Incorrect technique/training
l Ignoring early warning signs
m Lack the sense of self-protection
n Recurrence of old injury
o Inadequate diet/hydration
p Set/props
q Costume/shoes
r Improper Rehearsal schedule

s Accident

t Other, please explain briefly_____

END OF SURVEY

Thank you for taking the time to complete this survey

1c Questionnaire COVID-19 (Chinese version)

舞蹈专业学生损伤调查问卷 **(**改编自 **Fit to Dance 2)**

知情同意：请仔细阅读下列声明。阅读完后请你点击你是否愿意接受这则声明且很高兴将 您的答案用于此研究目的。

- 第一份调查重点是在过去 12 个月里，发生在舞蹈中的损伤。你将被要求填 写个人信息，包括你的年龄、身高和体重，你在哪里训练，你每天/周跳舞几 个小时等问题。此问卷 15 分钟内即可完成。
- 我知道我的信息将被完全地保密，并且每个人只会有一个唯一的标识码(下 一页)。
- 我知道我没有义务完成这项调查，并且我可以在任何时候出于任何原因停止 调查。
- 调查结果是保密的，且将只会与研究团队内的其他人讨论交流。

  你已满 18 岁___，你未满 18 岁___。

  如已满 18 岁,你接受这些声明，请点击此处___（开始填写问卷)； 如果你不接受这些声明，请点击此处___（结束，至感谢页面)。

  如未满 18 岁，你接受这些声明，请点击此处___(下一项)；且此声明也需父母同意。征得父母同意后，请点击此处___（开始填写问卷）如果你/父母不接受这些声明，请点击此处___（结束，至感谢页面）。

  日期_____年_____月_____日

个人标识码与个人信息

1. 你目前是(单选)?

   a. 舞蹈专业附中生
   b. 舞蹈专业本科生

2. 性别_____; 年龄_____(yrs); 体重_____(kg); 身高_____(cm). (单选)

3. 你就读于哪所学校?(单选)
   a. 北京舞蹈学院
   b. 天津体育学院
   c. 上海电影艺术学院
   d. 四川音乐学院
   e. 武汉体院
   f. 沈阳音乐学院

g. 河北民族师范学院
h. 上海戏剧学院
i. 南京艺术学院
j. 燕山大学
k. 其它，请填写_____

4. 你进入全日制舞蹈训练时是几岁?____ (如你是/曾是“附中生”，则填写你进入附中时的年龄;如您是“普高生”，则填写你进入本科时的年龄。单选)

5. 进入本科前，你的专业学习背景是?

a. 普高生
b. 舞蹈专业附中生

6. 你目前是几年级的学生? (单选)

a. 附中 1 年级
b. 附中 2 年级
c. 附中 3 年级
d. 附中 4 年级
e. 附中 5 年级
f. 附中 6 年级
g. 附中 7 年级
h. 本科 1 年级
i. 本科 2 年级
j. 本科 3 年级
k. 本科 4 年级
l. 其他，请补充————————

7. 你的主要舞种/专业是什么?(请注意分清 c、d、e 和 g 选项。单选)

a. 舞蹈学
b. 芭蕾舞
c. 现代舞/现代舞编导
d. 中国民族民间舞
e. 中国古典舞
f. 中国舞
g. 国际标准舞
h. 其它，请填写_____

8. 在学校关闭之前(疫情发生前，2020 年 2 月之前)，你平均每周花费几个 小时在下列选项中?(请填写下列每个选项，如果有个别项目没做，请选择 “0”)。

a. 专业课 _____小时
b. 排练 _____小时
c. 表演 _____小时
d. 身体素质训练(普拉提、跑步、健身操等) _____小时

学校关闭后(疫情期间，2020 年 2 月之后)，你平均每周花费几个小时在 下列选项中?(请填写下列每个选项，如果有个别项目没做，请选择“0”)。

a. 专业课 _____小时
b. 排练 _____小时
c. 表演 _____小时
d. 身体素质训练(普拉提、跑步、健身操等) _____小时

9. 你平均每晚睡几个小时? (单选)

a. 疫情前____小时
b. 疫情期间____小时

10. 你的疲劳程度是？(1-10, 1 代表不疲劳, 10 代表非常疲劳) (单选)

a. 疫情期间____
b. 疫情期间____

11. 你是否做热身活动?(单选)

a. 是
b. 否

11.1 如果“是”，多久?（如果你在下列选项之前做了热身活动，请选择符合你 情况的时长，如果在个别选项之前不做热身活动，请选择“0”）（单选）

	0	1-5	6-10	11-15	around 20	30 and more
a. 课前	___	___	___	___	___	___
b. 排练前	___	___	___	___	___	___
c. 演出前	___	___	___	___	___	___

12. 你是否做放松活动?(单选)

a. 是
b. 否

12.1 如果是，多久?(如果你在下列选项之后做了放松活动，请选择符合你情况的时长，如果在个别选项之后不做放松活动，请选择“0“)(单选)

	1-5	6-10	11-15	around 20	30 and more
a. 课前	___	___	___	___	___
b. 排练前	___	___	___	___	___
c. 演出前	___	___	___	___	___

13. 学校为热身活动预留时间了吗?（单选）

a. 是
b. 否

学校为放松活动预留时间了吗?

a. 是
b. 否

损伤信息

此研究中的舞蹈损伤被定义为发生在舞蹈中的身体问题，表现为 疼痛或不适，并导致舞者:作出相对应的调整动作以便继续跳舞、功 能障碍、活动幅度减小、甚至导致立即停止任何舞蹈活动。

14. 在过去的 12 个月里，你是否有损伤?(包括长期损伤，虽发生在 12 个月以前，但近 12 个月内仍持续影响你跳舞）(单选)

是_____ 否 _____

15. 如果你在过去 12 个月里有损伤，你损伤发生的部位在哪些部位?(多选题)

a. 胳膊(大臂和小臂)
b. 手
c. 肘关节
d. 腕关节
e. 肩关节
f. 颈部
g. 上背部(胸椎)
h. 下背部(腰椎)
i. 肋骨/胸廓
j. 骨盆

k. 髋关节
l. 大腿
m. 膝关节
n. 小腿
o. 踝关节
p. 足

16. 在过去的 12 个月里，在训练、排练和表演中你是否有下列损伤?(多选题)

a. 肌肉损伤
b. 骨损伤
c. 关节/韧带损伤
d. 腱损伤(肌腱或跟腱)
e. 其它损伤，请补充_____

17. 你的损伤严重程度是?（多选题）

a. 轻度(我仍可以跳舞，不受影响)
b. 中度(我必须在动作上作出适当的调整或有一些特定的动作做不了)
c. 中重度(少于 1 天不能跳舞)
d. 重度(一天或更长时间不能跳舞)
如果严重，共多少天? _____天(单选)

18. 在过去 12 个月里，你认为你的损伤原因是什么?(多选题)

a. 疲劳
b. 有限制的软度/柔韧性差
c. 不合适的地板
d. 环境温度低
e. 不充足/不适当的热身活动
f. 不充足/不适当的放松活动
g. 新的/难度大的编舞
h. 不同的剧目
i. 重复的动作
j. 搭档合作
k. 不正确的技巧/训练
l. 忽视早期警告信号
m. 缺乏自我保护意识
n. 旧伤复发
o. 饮食/补水不足
p. 舞台场景/道具
q. 服装/鞋
r. 不合适的排练计划

s. 意外
t. 其它，请补充_____

19. 因为你的损伤，你寻求过哪些专业的帮助?（多选题）

a. 理疗师
b. 医生
c. 正骨/整骨
d. 整脊师
e. 按摩
f. 针灸
g. 营养学家
h. 心理学家
i. 普拉提
j. 没有做任何措施
k. 其它，请补充_____

20. 如果你猜想自己有损伤，你会怎么做?(多选)

a. 寻找专业的医学治疗
b. 告诉其他人
c. 自己采取预防措施
d. 吃止痛药
e. 继续跳舞，但小心点儿
f. 忽视它
g. 隐藏它
h. 其它，请补充_____

21. 谁是指导你返回舞蹈训练过程中最影响你的人?(多选题)

a. 专业医疗/理疗师
b. 老师
c. 你自己
d. 其它，请补充_____

22. 在本次疫情期间(2020 年 2 月份-至今)你是否在上过网络课程?是____ 否____ (单选)

23. 如果“是”，网课持续多久了? (单选题)

a. 1 个月
b. 2 个月
c. 3 个月
d. 4 个月

e. 5 个月
f. 6 个月
g. 超个 6 个月

24. 疫情隔离在家期间，你在_____上跳舞?

a. 家用木地板
b. 瓷砖
c. 地毯
d. 瑜伽垫
e. 个人舞蹈室地板(地胶)
f. 其它，请补充_____

25. 在此次疫情隔离在家期间，你是否有舞蹈损伤的发生?是 _ 否_? (单选题)

26. 发生在哪些部位? (“有“损伤)

a. 胳膊(大臂和小臂)
b. 手
c. 肘关节
d. 腕关节
e. 肩关节
f. 颈部
g. 上背部(胸椎)
h. 下背部(腰椎)
i. 肋骨/胸廓
j. 骨盆
k. 髋关节
l. 大腿
m. 膝关节
n. 小腿
o. 踝关节
p. 足

27. 在过去的 12 个月里，在训练、排练和表演中你是否有下列损伤?(多选题)

a. 肌肉损伤
b. 骨损伤
c. 关节/韧带损伤
d. 腱损伤(肌腱或跟腱)
e. 其它损伤，请补充_____

28. 如果“有损伤”，你的损伤严重程度属于?(多选题)

a. 轻度(我仍可以跳舞，不受影响)
b. 中度(我必须在动作上作出适当的调整或有一些特定的动作做不了)
c. 中重度(少于 1 天不能跳舞)
d. 重度(一天或更长时间不能跳舞)
如果严重，共多少天? _____天(单选)

29. 在过去 12 个月里，你认为你的损伤原因是什么?(多选题)

a. 疲劳
b. 有限制的软度/柔韧性差
c. 不合适的地板
d. 环境温度低
e. 不充足/不适当的热身活动
f. 不充足/不适当的放松活动
g. 新的/难度大的编舞
h. 不同的剧目
i. 重复的动作
j. 搭档合作
k. 不正确的技巧/训练
l. 忽视早期警告信号
m. 缺乏自我保护意识
n. 旧伤复发
o. 饮食/补水不足
p. 舞台场景/道具
q. 服装/鞋
r. 不合适的排练计划
s. 意外
t. 其它，请补充_____

调查结束

非常感谢你花费时间完成这项调查

2a Recall Survey Questionnaire in English (First Week)

Recall Survey for Dance Injury

Informed consent:

Please read the following statements carefully. At the end you will be able to click whether you accept this statement and are happy for your answers to be used for research purposes.

- This survey will be sent to you every week for you to record what happened in the preceding week (injuries, dance activity, etc), this will take only 3-5 minutes to complete.

- I know my information will be totally confidential and I will only be recognised by a unique Wechat Account and student number.

- I know that I am not obliged to complete the survey and that I can stop the survey at any point and for any reason.

- The survey results are confidential and will only be communicated to others within the research team.

1. Are you over 18 years old? Yes_____ No_____.

2. If yes. Please click whether you accept these statements? Yes_____ (nest page) No_____.

3. If no. Please note that these statements require the consent of you and your parents. Please click whether you all accept these statements? (If you all agree, please click "yes", if one of you or you all disagree please click "no".)

   Yes_____ (nest page) No_____.

General information

Gender: ___Age: ___Height: ___Body mass: ___

1 Student number: ___

2 School's name: ___

3 Dance genres/major: ___

4 Year of class/grade: ___

5 The amount of exercise in last week?

a Technique /professional classes number of hours_____
b Rehearsal number of hours _____
c Performing number of hours _____
d Body conditioning training number of hours _____

6 What do you think the intensity of your exercise in this week___? the scales from 1 to10. (single choice) (“1” means very low, “10” means very huge.)

7 How tired did you feel last week? ___ the scales from 1 to10. (single choice) (“1” means you don’t feel tired, “10” means you are very tired.)

8 What was you sleep quality last week? __ the scales from 1 to 10. (single choice) (“1” means very bad, “10” means very good.)

9 How well did you eat last week? __ the scales from 1 to 10. (single choice) (“1” means very bad, “10” means very good.)

Dance Injury

Dance Injury is defined as a physical problem that happened whilst dancing, which represents/shows pain or discomfort and results in modified participation, dysfunction, reduced range of movement and even stopping you immediately in any dance activity.

Injury Incidence

10 Did you have injury in this week?

a Yes
b No

11 If “Yes”. Where were the sites of the injury? (multiple choices)

a. Upper and/or lower arms (Site 1)
b. Hands
c. Elbow joints
d. Wrist
e. Shoulder

f. Neck
g. Upper back
h. Lower back
i. Ribs
j. Pelvis/Hips
k. Hip joints/Groin
l. Thighs
m. Knees
n. Lower legs
o. Ankles (Achilles's tendon)
p. Feet (Site 16)

12 Your upper and/or lower arms (Site 1) injury is:

a New injury (just happened in this week)
b Old injury (happened in last week and still affecting you this week)

13 Site 1: Which side of this injury? (single choice)

a Left
b Right
c Both

14 Site 1: What the tissue of injury? (multiple choice)

a Muscle
b Bone
c joint/ligament
d tendon
e other, please define _____

15 Site 1: How often and how many times?

a) Occasional, times_____
b) on and off in special movement, times_____
c) on and off in non-special movement, times_____
d) Continue

16 How severity was of your injury? (multiple choice)

a Minor (feel pain/uncomfortable, but I can still dance)
b Moderate (I have to adapt my movement or can't do certain movements)
c Moderate to Severe (break off but less than 1 day)
d Severe (can't dance for at least 1 day or more than 1 day)

If severe, how many days can take those ones? ___days (single choice)

17 Site 1: What kind of dance activity you were in when your injury happened? (single choice)

a Dance class/Technique class
b Performance
c Rehearsal
d Morning training
e Night training
f Other, please specify___

18 Site 1: What kind of training were you doing when you got injury? And try your best to write the acute movement name and process (For example：Flexibility training: leg stretching on the bar; Jumping technique: Lingkong Jump landing) (multiple)

a Flexibility training _____
b Jumping technique _____
c Twirl technique _____
d Writhe technique _____
e Controlling technique _____
f Dance Posture _____
g Any Squat training _____
h Other, please specify_____

Q12-18 for Each Site: Site 2, Site 3 …… Site16

Causes of injury

19 What do you think was the cause of the injury? (multiple choice)

a Fatigue
b Limited/bad flexibility
c Unsuitable floor
d Cold environment
e Insufficient warm up
f Insufficient cool down
g New/difficult choreography
h Repetitive movement

i Partnering work

j Incorrect technique/training

k Ignoring early warning signs

l Lack the sense of self-protection

m Recurrence of old injury

n Inadequate diet/hydration

o Set/props

p Costume/shoes

q Rehearsal schedule

r Accident

s Other, please explain briefly_____

Treatment and Rehabilitation

20 Were you receiving treatment for your injury in this present week? Yes___ No___

21 If Yes. What type of professional help did you have for your injuries? (multiple choice)

a) Physiotherapist
b) Doctor/PG
c) Osteopath
d) Chiropractor
e) Masseur
f) Acupuncturist
g) Dietician
h) Psychologist
i) Pilates
j) Rehabilitation Exercise
k) Other, please specify_____

22 If yes. How many sessions you had in this week? ____

23 How do you think of its effect? (1-10, “1” means very bad, “10” means very good.)

END OF SURVEY.

Thank you for taking the time to complete this survey.

2b Recall Survey Questionnaire in Chinese (First Week)

舞蹈损伤跟踪调查

知情同意：

请仔细阅读下列声明。阅读完后请你点击你是否愿意接受这则声明且很高兴将您的答案用于此研究目的。

- 每周都向你发送此调查问卷，以记录上一周发生的情况（损伤、舞蹈活动等）。只需 3-5 分钟即可完成。
- 我知道我的信息将被完全地保密，并且我将只有一个唯一的标识码（微信昵称和学号）。
- 我知道我没有义务完成这项调查，并且我可以在任何时候出于任何原因停止调查。
- 调查结果是保密的，且将只会与研究团队内的其他人讨论交流。

1. 你是否满 18 岁？是・___ 否・___
2. 如果是。你是否接受这些声明？是__ 否___。
3. 如果否，则此声明也需父母同意。如果你们都接受这些声明，请点击此处是・（下一页，开始填写问卷）；有任何一方不接受，选否（结束，至感谢页面）。

   是・___ 否・___

一般信息

性别： 男___ 女___; 年龄：___; 身高：___; 体重：___

1. 学号：___
2. 学校名字：___
3. 舞种/专业：___
4. 年级：___

5. 上周，你在下列运动中分别花费几小时？

a 专业课 _____小时
b 排练 _____小时
c 表演 _____小时
d 身体素质训练（普拉提、跑步、健身操等） _____小时

6. 你上周的训练强度如何? __（1-10, 1 代表不疲劳, 10 代表非常疲劳；单选）

7. 你上周的疲劳程度如何? __（1-10, 1 代表不疲劳, 10 代表非常疲劳；单选）

8. 你上周的睡眠质量如何？__ (1-10, 1 代表非常不好, 10 代表非常好；单选)

9. 你上周的饮食情况如何？__ (1-10, 1 代表非常不好, 10 代表非常好；单选)

舞蹈损伤

此研究中的舞蹈损伤被定义为发生在舞蹈中的身体问题，表现为疼痛或不适，并且导致舞者作出相对应的调整以便继续跳舞、功能障碍、活动幅度减小、甚至导致你立即停止任何舞蹈活动。

损伤发生率

10. 在即将过去的这周，你是否有损伤？

a. 是
b. 否

11. 你新伤发生的部位？(多选题)

a. 胳膊(大臂和小臂)
b. 手
c. 肘关节
d. 腕关节
e. 肩关节
f. 颈部
g. 上背部(胸椎)
h. 下背部(腰椎)
i. 肋骨/胸廓
j. 骨盆
k. 髋关节

l. 大腿
m. 膝关节
n. 小腿
o. 踝关节
p. 足

12. 部位 1：属于：

a 新伤（上周未出现，但这周出现了）
b 旧伤（上周出现，这周仍持续影响你）

13. 部位 1：发生在此部位的哪侧？（单选）

a 左
b 右
c 两侧/中间（躯干）

14. 部位 1: 此部位损伤是什么类型？(多选)

a 肌肉损伤
b 骨损伤
c 关节/韧带损伤
d 肌腱或跟腱损伤
e 其它，请补充_____

15. 部位 1:频率和次数？

a 偶尔一次，次数为_____
b 断断续续，时有时无（特定动作），次数为_____
c 断断续续，时有时无（非特定动作），次数为_____
d 持续性，时好时坏

16. 部位 1:严重程度是？ (多选题)

a. 轻度(我仍可以跳舞，不受影响)
b. 中度(我必须在动作上作出适当的调整或有一些特定的动作做不了)
c. 中重度(少于 1 天不能跳舞)
d. 重度(一天或更长时间不能跳舞)
如果严重，共多少天？_____天(单选)

17. Site1:你的损伤发生在下列哪些情况下？ (多选)

a 舞蹈专业课（不包括理论课，如舞蹈史论等不涉及身体运动的课程）
b 演出

c 排练
d 早功
e 晚功
f 其它，请补充___

18. Site 1:损伤发生时，你在做哪类训练中？ (单选)

a 软度训练
b 跳类技巧
c 转类技巧
d 翻类技巧
e 控制类技巧
f 舞姿
g 蹲类训练
h 其它, 请补充_____

第 2，第 3……第 16 个部位都会针对性的问问题 12 到 18

损伤原因

19. 你认为造成你新伤发生的原因是什么？ (多选)

a 疲劳
b 有限制的软度/柔韧性差
c 不合适的地板
d 环境温度低
e 不充足/不适当的热身活动
f 不充足/不适当的放松活动
g 新的/难度大的编舞
h 重复的动作
i 搭档合作
j 不正确的技巧/训练
k 忽视早期警告信号
l 缺乏自我保护意识
m 旧伤复发
n 饮食/补水不足
o 舞台场景/道具
p 服装/鞋
q 不合适的排练计划
r 意外
s 其它，请补充_____

治疗和康复

20. 在即将过去的这周，你是否结果了治疗或康复？

是___ 否 ___

21. 如果是，你接受了哪些治疗/康复？（多选）

a) 理疗师
b) 医生
c) 正骨/整骨
d) 整脊师
e) 按摩
f) 针灸
g) 营养学家
h) 心理学家
i) 普拉提
j) 康复师/康复训练
k) 其它，请补充_____

22. 如果是，你共接收了几次治疗/康复？____

23. 你认为以上这些治疗/康复效果如何____？ （1-10）

调查结束

非常感谢你花费时间完成这项调查。

2c Recall Survey Questionnaire in English (Weekly)

Recall Survey for Dance Injury

General information

1 Student number: ___

2 School's name: ___

3 Dance genres/major: ___

4 Year of class/grade: ___

5 The amount of exercise in last week?

a Technique /professional classes number of hours_____
b Rehearsal number of hours _____
c Performing number of hours _____
d Body conditioning training number of hours _____

6 What do you think the intensity of your exercise in this week___? the scales from 1 to10. (single choice) ("1" means very low, "10" means very huge.)

7 How tired did you feel last week? ___ the scales from 1 to10. (single choice) ("1" means you don't feel tired, "10" means you are very tired.)

8 What was you sleep quality last week? __ the scales from 1 to 10. (single choice) ("1" means very bad, "10" means very good.)

9 How well did you eat last week? __ the scales from 1 to 10. (single choice) ("1" means very bad, "10" means very good.)

Dance Injury

Dance Injury is defined as a physical problem that happened whilst dancing, which represents/shows pain or discomfort and results in modified participation, dysfunction, reduced range of movement and even stopping you immediately in any dance activity.

Injury Incidence

10 Did you have injury in this week?

a Yes (if yes then question below will be available)
b No

11 If “Yes”. Where were the sites of the injury? (multiple)

a. Upper and/or lower arms (Site 1)
b. Hands
c. Elbow joints
d. Wrist
e. Shoulder
f. Neck
g. Upper back
h. Lower back
i. Ribs
j. Pelvis/Hips
k. Hip joints/Groin
l. Thighs
m. Knees
n. Lower legs
o. Ankles (Achilles’s tendon)
p. Feet (Site 16)

12 Your upper and/or lower arms (Site 1) injury is:

a New injury (just happened in this week)
b Old injury (happened in last week and still affecting you this week) (Q13-18 will be hidden)

13 Site 1: Which side of this injury? (single)

a Left
b Right
c Both

14 Site 1: What the nature? (multiple)

a Muscle
b Bone
c joint/ligament
d tendon
e other, please define _____

15 Site 1: How often and how many times?

a) Occasional, times_____
b) on and off in special movement, times_____
c) on and off in non-special movement, times_____
d) Continue

16 Site 1: How severity was of your injury? (multiple)

a Minor (feel pain/uncomfortable, but I can still dance)
b Moderate (I have to adapt my movement or can't do certain movements)
c Moderate to Severe (break off but less than 1 day)
d Severe (can't dance for at least 1 day or more than 1 day)
If severe, how many days can take those ones? ___days (single choice)

17 Site 1: What kind of dance activity you were in when your injury happened? (single)

a Dance class/Technique class
b Performance
c Rehearsal
d Morning training
e Night training
f Other, please specify___

18 Site 1: What kind of training were you doing when you got injury? And try your best to write the acute movement name and process (For example：Flexibility training: leg stretching on the bar; Jumping technique: Lingkong Jump landing) (multiple)

a Flexibility training _____
b Jumping technique _____
c Twirl technique _____
d Writhe technique _____
e Controlling technique _____
f Dance Posture _____
g Any Squat training _____
h Other, please specify_____

Q12-18 for Each Site: Site 2, Site 3 …… Site16

Causes of injury

19 What do you think was the cause of the injury? (multiple choice)

a Fatigue
b Limited/bad flexibility
c Unsuitable floor

d Cold environment
e Insufficient warm up
f Insufficient cool down
g New/difficult choreography
h Repetitive movement
i Partnering work
j Incorrect technique/training
k Ignoring early warning signs
l Lack the sense of self-protection
m Recurrence of old injury
n Inadequate diet/hydration
o Set/props
p Costume/shoes
q Rehearsal schedule
r Accident
s Other, please explain briefly_____

Treatment and Rehabilitation

20 Were you receiving treatment for your injury in this present week? Yes/No

21 If Yes. What type of professional help did you have for your injuries? (multiple)
a) Physiotherapist
b) Doctor/PG
c) Osteopath
d) Chiropractor
e) Masseur
f) Acupuncturist
g) Dietician
h) Psychologist
i) Pilates
j) Rehabilitation Exercise
k) Other, please specify_____

22 If yes. How many sessions you had in this week? ____

23 How do you think of its effect? (1-10,“1”means very bad, “10” means very good.)

END OF SURVEY

Thank you for taking the time to complete this survey.

2d Recall Survey Questionnaire in Chinese (Weekly)

舞蹈损伤跟踪调查

一般信息

性别： 男___ 女___; 年龄：___; 身高：___; 体重：___

1. 学号：___

2. 学校名字：___

3. 舞种/专业：___

4. 年级：___

5. 上周，你在下列运动中分别花费几小时？

   a 专业课 _____小时
   b 排练 _____小时
   c 表演 _____小时
   d 身体素质训练（普拉提、跑步、健身操等） _____小时

6. 你上周的训练强度如何？__（1-10, 1 代表不疲劳, 10 代表非常疲劳；单选）

7. 你上周的疲劳程度如何？__（1-10, 1 代表不疲劳, 10 代表非常疲劳；单选）

8. 你上周的睡眠质量如何？__ (1-10, 1 代表非常不好, 10 代表非常好；单选)

9. 你上周的饮食情况如何？__ (1-10, 1 代表非常不好, 10 代表非常好；单选)

舞蹈损伤

此研究中的舞蹈损伤被定义为发生在舞蹈中的身体问题，表现为疼痛或不适，并且导致舞者作出相对应的调整以便继续跳舞、功能障碍、活动幅度减小、甚至导致你立即停止任何舞蹈活动。

损伤发生率

10. 在即将过去的这周，你是否有损伤？

    a. 是 (如果是，下列问题将会出现)
    b. 否

11. 你新伤发生的部位？(多选题)
    a. 胳膊(大臂和小臂)
    b. 手
    c. 肘关节
    d. 腕关节
    e. 肩关节
    f. 颈部
    g. 上背部(胸椎)
    h. 下背部(腰椎)
    i. 肋骨/胸廓
    j. 骨盆
    k. 髋关节
    l. 大腿
    m. 膝关节
    n. 小腿
    o. 踝关节
    p. 足

12. 部位 1：属于：
    a 新伤（上周未出现，但这周出现了）
    b 旧伤（上周出现，这周仍持续影响你）(如果否，下列问题将会隐藏)

13. 部位 1：发生在此部位的哪侧？（单选）
    a 左
    b 右
    c 两侧/中间（躯干）

14. 部位 1: 此部位损伤是什么类型？(多选)
    a 肌肉损伤
    b 骨损伤
    c 关节/韧带损伤
    d 肌腱或跟腱损伤
    e 其它，请补充_____

15. 部位 1:频率和次数？

a 偶尔一次，次数为_____
b 断断续续，时有时无（特定动作），次数为_____
c 断断续续，时有时无（非特定动作），次数为_____
d 持续性，时好时坏

16. 部位 1:严重程度是？ (多选题)
a. 轻度(我仍可以跳舞，不受影响)
b. 中度(我必须在动作上作出适当的调整或有一些特定的动作做不了)
c. 中重度(少于 1 天不能跳舞)
d. 重度(一天或更长时间不能跳舞)
如果严重，共多少天？_____天(单选)

17. 部位 1:你的损伤发生在下列哪些情况下？ (多选)
a 舞蹈专业课（不包括理论课，如舞蹈史论等不涉及身体运动的课程）
b 演出
c 排练
d 早功
e 晚功
f 其它，请补充___

18. 部位 1:损伤发生时，你在做哪类训练中？ (单选)
a 软度训练
b 跳类技巧
c 转类技巧
d 翻类技巧
e 控制类技巧
f 舞姿
g 蹲类训练
h 其它, 请补充_____

第 2，第 3……第 16 个部位都会针对性的问问题 12 到 18

损伤原因

19. 你认为造成你新伤发生的原因是什么？ (多选)

a 疲劳
b 有限制的软度/柔韧性差
c 不合适的地板
d 环境温度低
e 不充足/不适当的热身活动
f 不充足/不适当的放松活动
g 新的/难度大的编舞

h 重复的动作
i 搭档合作
j 不正确的技巧/训练
k 忽视早期警告信号
l 缺乏自我保护意识
m 旧伤复发
n 饮食/补水不足
o 舞台场景/道具
p 服装/鞋
q 不合适的排练计划
r 意外
s 其它，请补充_____

治疗和康复

20. 在即将过去的这周，你是否结果了治疗或康复？

是___ 否 ___

21. 如果是，你接受了哪些治疗/康复？（多选）
    a) 理疗师
    b) 医生
    c) 正骨/整骨
    d) 整脊师
    e) 按摩
    f) 针灸
    g) 营养学家
    h) 心理学家
    i) 普拉提
    j) 康复师/康复训练
    k) 其它，请补充_____

22. 如果是，你共接收了几次治疗/康复？____

23. 你认为以上这些治疗/康复效果如何____？ （1-10）

调查结束

非常感谢你花费时间完成这项调查。

3a Valid data

Institutions	Survey period	Semester	90% of whole survey period	Final included weeks	Valid data (n)
1	30 weeks	Over two semesters	27	27	1
2.1	30 weeks	Over two semesters	27	27	28
3	30 weeks	Over two semesters	27	27	24
4	30 weeks	Over two semesters	27	27	7
2.1	28(2 weeks gap)	Over two semesters	25.2	25	38
5	27 weeks	Over two semesters	24.3	24	16
6	27 weeks	Over two semesters	24.3	24	39
7	24 weeks	Over two semesters	21.6	22	48
8	24 weeks	Over two semesters	21.6	22	9
					210
9	13 weeks	In the first semester	11.7	11	75
10	13 weeks	In the first semester	11.7	11	31
11	13 weeks	In the first semester	11.7	11	24
2	13 weeks	In the first semester	11.7	11	33
5	12 weeks	In the first semester	10.8	10	58
6	10 weeks	In the first semester	9	9	19
					240

3b Participants Anthropometrics

Anthropometrics	**Full cohort**		**AMS**		**US**	
Group (n)	**450**		**110**		**340**	
Age	18.4±2.18		15.3±1.33		19.5±1.19†	
Height (cm)	168.2±6.31		167.9±6.16		168.2±6.37	
Body mass (kg)	53.7±8.75		50.4±5.65		54.8±9.29†	
BMI	18.95±2.62		17.83±1.26		19.32±2.83†	
Weekly exposure (hrs)	32.2±16.13		29.3±14.50		33.2±16.53*	
Gender	**Male (n=91)**	**Female (n=359)**	**Male (n=23)**	**Female (n=87)**	**Male (n=68)**	**Female (n=272)**
Age	18.1±2.23	18.5±2.17*	14.9±0.87	15.34±1.41	19.2±1.28	19.5±1.15†
Height (cm)	177.1±5.33†	165.9±4.19	175.1±5.36†	166.0±4.82	177.7±5.19†	165.9±3.98
Body mass (kg)	62.4±7.50†	51.5±7.61	56.5±7.20†	48.7±3.82	64.4±6.50†	52.4±8.28
BMI	19.87±1.91†	18.72±2.72	18.38±1.80*	17.68±1.03	20.38±1.67†	19.05±3.00
Weekly exposure (hrs)	33.3±15.85	32.0±16.21	31.5±13.73	28.8±14.72	33.9±16.55	33.0±16.55

3c Participants anthropometrics by dance genres

	Dancology (n=222)		Ballet (n=11)		Contemporary (n=12)		Chinese Dance (n=126)		DanceSport (n=59)		Musical Theatre (n=20)	
Group (n)	**222**		**11**		**12**		**126**		**59**		**20**	
Age	19.3±1.69		20.4±2.06		19.3±0.62		16.8±2.28		18.9±0.98		16.1±2.40	
Height (cm)	167.0±5.65		172.4±6.33		167.9±5.42		168.9±6.49		170.1±7.88		168.9±4.74	
Weight (kg)	53.9±9.60		56.0±8.82		56.2±8.89		51.9±6.80		57.3±9.13		50.9±3.70	
BMI	19.30±3.29		18.74±1.86		19.85±1.96		18.12±1.38		19.67±1.69		17.84±1.13	
Weekly hours	33.71±16.80		32.43±17.47		41.24±15.02		32.24±15.17		28.31±14.28		21.83±14.05	
Gender	**Male (n=30)**	**Female (n=192)**	**Male (n=5)**	**Female (n=6)**	**Male (n=2)**	**Female (n=10)**	**Male (n=30)**	**Female (n=96)**	**Male (n=20)**	**Female (n=39)**	**Male (n=4)**	**Female (n=16)**
Age	19.0±0.99	19.3±1.77*	21.0±2.83	19.83±1.17	19.0±0.00	19.3±0.68	16.6±2.44	16.9±2.24	18.9±0.85	18.9±1.05	14.5±1.29	16.5±2.48
Height (cm)	176.2±5.58†	165.5±4.10	176.7±5.85*	168.8±4.36	177.0±4.24*	166.1±3.43	177.2±5.08†	166.2±4.31	179.1±4.68†	165.5±4.49	172.9±7.28	167.9±3.56
Weight (kg)	62.5±5.28†	52.5±9.43	64.0±5.43†	49.3±3.83	70.0±14.14*	53.5±4.84	59.6±7.70†	49.4±4.21	67.1±7.62†	52.2±4.68	53.6±1.70	50.2±3.78
BMI	20.14±1.59†	19.17±3.46	20.47±0.86†	17.29±0.91	22.25±3.45	19.36±1.35	18.92±1.74†	17.87±1.14	20.89±1.89†	19.04±1.17	18.00±1.33	17.81±1.12
Weekly hours	36.03±18.92	33.34±16.47	40.25±24.23	25.92±5.31	33.15±7.82	42.86±15.85	30.23±12.41	32.87±15.94	31.08±12.39	26.89±15.12	37.78±22.36*	17.84±8.07

3d Weekly IP by dance genres

	Number	Got injured	No injury	IP	Average weekly IP
Combined all groups	450	292	158	64.89%	15.0%
Dancology	222	153	69	68.92%	12.8%
Ballet	11	10	1	90.91%	47.2%
Contemporary dance	12	10	2	83.33%	58.8%
Chinese Dance	126	84	42	66.67%	17.5%
DanceSport	59	21	38	35.59%	3.4%
Musical Theatre	20	14	6	70.00%	21.3%

Weekly IP by dance genres (continuing)

	Semester 1												
	Week 1	2	3	4	5	6	7	8	9	10	11	12	13
Combined all genres	45.2%	30.7%	27.9%	21.7%	20.6%	18.5%	17.7%	15.7%	13.0%	17.6%	17.1%	21.0%	17.5%
Dancology	47.66%	24.88%	25.24%	17.81%	17.22%	15.21%	15.53%	11.80%	7.34%	20.67%	15.73%	23.16%	20.95%
Ballet	90.00%	63.64%	63.64%	72.73%	72.73%	54.55%	63.64%	45.45%	54.55%	45.45%	40.00%	27.27%	20.00%
Contemporary dance	41.67%	66.67%	75.00%	50.00%	63.64%	54.55%	58.33%	41.67%	33.33%	33.33%	33.33%	36.36%	25.00%
Chinese Dance	48.67%	40.38%	30.58%	25.20%	22.58%	21.43%	19.20%	19.83%	20.00%	12.07%	14.91%	16.07%	13.08%
DanceSport	22.03%	16.95%	13.56%	10.17%	6.78%	6.78%	3.39%	5.08%	1.69%	5.00%	0.00%	0.00%	0.00%
Musical dance	46.67%	47.06%	35.00%	33.33%	31.58%	30.00%	25.00%	33.33%	25.00%	25.00%	25.00%	16.67%	18.18%

Semester 2																
Week 14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
14.0%	9.0%	9.5%	10.6%	11.4%	8.8%	10.2%	10.2%	8.3%	12.7%	11.1%	9.0%	11.1%	8.5%	8.9%	7.9%	5.9%
10.53%	6.67%	7.89%	8.00%	6.85%	2.63%	8.11%	5.41%	8.00%	6.67%	8.33%	5.48%	9.21%	5.48%	6.45%	8.82%	5.08%
28.57%	42.86%	50.00%	57.14%	50.00%	37.50%	37.50%	37.50%	37.50%	50.00%	37.50%	37.50%	42.86%	37.50%	37.50%	42.86%	37.50%
100.00%	50.00%	50.00%	50.00%	50.00%	100.00%	50.00%	50.00%	100.00%	100.00%	100.00%	50.00%	50.00%	50.00%	50.00%	50.00%	100.00%
17.14%	11.11%	11.11%	13.89%	14.08%	13.24%	16.67%	22.86%	8.45%	21.74%	15.28%	13.24%	14.08%	8.45%	10.29%	5.08%	4.41%
5.00%	0.00%	0.00%	0.00%	2.78%	2.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
25.00%	16.67%	8.33%	8.33%	18.18%	16.67%	11.11%	11.11%	8.33%	8.33%	8.33%	9.09%	27.27%	27.27%	16.67%	16.67%	8.33%

3e Incidence by genres and genders

	All genres	**Dancology**	**Ballet**	**Contemporay**	**Chinese Dance**	**DanceSport**	**Musical Theatre**
Total	5.51	7.47	8.01*	4.94	3.67	2.18	4.14
Female	6.05	7.83	8.94	4.96	4.14	2.29	4.84
Male	3.39	5.12	6.9	4.85	2.18	1.98	1.33

3f Injury severity by genres

	Minor	**Moderate**	**Moderate to severe**	**Severe**
Dancology	68.44%	25.16%	3.66%	2.74%
Ballet	34.02%	56.22% ‡ (p<0.01)	7.44% ‡ (p<0.01)	2.31%
Contemporary	67.48%	25.48%	0.37%	0.00%
Chinese dance	28.01%	56.51% ‡ (p<0.01)	9.50% ‡ (p<0.01)	5.98%* (p<0.05)
Dancesport	19.07%	23.33%	0.82%	0.11%
Musical Theatre	12.64%	46.18% * (p<0.05)	2.64%	28.54% ‡ (p<0.01)

3g Main injury sites by levels and genders

	Shoulders	Lower back	Groin	Knees	Ankles	Feet
Full cohort	0.49	0.80	0.56	0.89	0.41	0.58
FC F	0.56	0.92	0.64	1.02	0.42	0.56
FC M	0.21	0.35	0.25	0.37	0.34	0.69
AMS	0.20	1.23	1.02	0.75	0.39	0.36
AMS F	0.25	1.50	1.15	0.93	0.44	0.41
AMS M	0.00	0.19	0.53	0.06	0.17	0.17
US	0.59	0.67	0.41	0.93	0.41	0.66
US F	0.66	0.73	0.48	1.05	0.42	0.60
US M	0.28	0.41	0.15	0.48	0.39	0.86

4a Ethical approval letter

University of Wolverhampton
Faculty of Education Health & Wellbeing
Gorway Road
Walsall
WS1 3BD
T: + 44 01902 321000
www.wlv.ac.uk

12th November 2021

Yanan Dang
University of Wolverhampton
FEHW

Dear Rebekah

Re: The Impact of Strength and Conditioning Training on dance injury, physical fitness and dance performance in Chinese dance students

The Faculty Ethics Panel (Sports) has considered and reviewed your submission.

On review your Research Proposal was passed and the Panel believes that the ethical issues inherent in your study have been adequately considered and addressed. Therefore the Panel is giving you full ethical approval for your study (Code 1 – Approved –Unique code: (11/21/YD/UOW).

You are required to report any adverse effects within the research process to this Ethics Committee, and to resubmit for approval if a project requires amendment. Also at the end of the project could you inform the Committee that the project has ended and met its stated outcomes.

We would like to wish you every success with the project.

Yours sincerely

[redacted]

Head of Doctoral Studies
Chair – Faculty Ethics Committee

Dean: Professor Damien Page
University of Wolverhampton, Faculty of Education Health and Wellbeing, Gorway Road, Walsall Campus, Walsall WS1 3BD, United Kingdom
T: +44 01902 321000 W: www.wlv.ac.uk

4b Strength and Conditioning Training Informed Consent

Informed consent:

Please read the following statements carefully. In the end, you will be able to click whether you accept this statement and are happy to participate in our training intervention to be used for research purposes.

- The purpose of this strength and conditioning training is to decrease injury prevalence and severity and improve physical fitness and dance performance levels. You will receive training 2-time/week, 30-minute/time, for 14-week. In addition, we will assess your physical fitness and dance performance level pre and post-training.

- I know my information will be totally confidential and I will only be recognised by a unique identifier code (school name and student number).

- I know that I am not obliged to complete the training and that I can stop the survey at any point and for any reason.

- The assessment results are confidential and will only be communicated to others within the research team.

1. If you are over 18-year-old? Yes □ No □

2. If you are over 18-year-old, please click here if you accept these statements □

3. If you are under 18-year-old, please click here if you and your parents accept this statement □

Date .....

4c Physical Fitness Test

School_____ Student number _____ Gender_____ Age _____ Height(cm) _____Body weight (kg)_____Time_____

	Test movements	Target	How long (seconds) or how many (times)	Results
1	Plank (straight legs)	Whole	How long	
2	Calf raise (left)	Ankles, feet and calf	How many	
	Calf raise (right)		How many	
3	Side-plank（left）	Side core	How long	
	Side-plank (right)		How long	
4	Split squat (left)	Legs and hips	How many	
	Split squat (right)		How many	
5	Press-up (knees bend)	Arms, shoulders and upper trunk	How many	
6	Straight legs raise	Abs, front core	How many	
7	Vertical Jump (in first position)	Lower legs	How height (cm)	

4d Brief Description of Performance Assessment Variables

School_____ Student number _____ Time_____

N	Variables	Definition	Results
1	Coordination	Whole body moving harmoniously	1-10
2	Control of movement	Controlled landing from jumps and turns, controlled lifting/lowering of limbs, controlled shifting of body weight	1-10
3	Spatial awareness/skills	Awareness of dance space and peripheral space	1-10
4	Accuracy of movement	Correct classical ballet arm placement, accurate foot positions (closings etc), fully stretched leg extensions where required, technical accuracy within the realms of classical ballet technique	1-10
5	Skill level (virtuosity)/ technique	High jumps, high leg extensions, multiple turns, "batterie" in allegro movements	1-10
6	Timing and rhythmical accuracy	Dancing with accurate timing, in time with musical accompaniment	1-10
7	Response to phrasing and dynamics	Showing not only an awareness for changes in musical dynamics and phrasing but responding to them appropriately. Showing the appropriate dynamic for each movement	1-10
8	Expression and interpretation	Showing expression throughout the whole body	1-10
9	Communication/projection	Performing to an audience, using a varied eye-contact and projection of emotion where appropriate	1-10

10	Overall performance qualities	The performance, as a whole, evoking an emotional response from the audience/assessor	1-10

4e Intervention Details

Each exercise for 50-second with a 10-second change, after every 3-exercise, have 1-minute jumps as skipping to keep heart rate at a certain level.

N	**Exercises**	**Circuit 1 (mat)**	**Circuit 2（mat+band）**	**Circuit 3**	**Circuit 4**
1	UB	Press up	Bicep curls	Deadlift with band	Chest press
2	Core	Plank	Straight legs raise	Plank shoulder taps	Seated trunk rotation
3	LB	Calf raise (left)	Prone straight legs raise	Bridge	Relive (straight leg)
	Skipping				
4	UB	Walkout	Triceps extension	Mountain climbing	Band/Dumbbell lateral raises
5	Core	Side-plank (left)	Abdominal curls	Ankle touch	Trunk rotation with band(left)
6	LB	Calf raise (right)	Split squat (left)	Side-lunge	Demi-Plie in second position
	Skipping				
7	UB	Bear crawl	Upright row	Seated row	Overhead triceps extension
8	Core	Side-plank (right)	Dead bugs	Bird dogs	Trunk rotation with band(right)
9	LB	Squat	Split squat (right)	Fire hydrants	Lying leg curls

Please note that “UB” and “LB” mean “upper body” and “lower body”

4f Training Load Each Week

Week	Number of sessions	Circuit	Number of circuits
Week 1/14	Physical fitness Test and dance performance assessments		
Week 2	2	1	2
Week 3	1	1	3
	1	2	2
Week 4	1	2	3
	1	3	2
Week 5	1	2	3
	1	3	3
Week 6	1	3	3
	1	4	2
Week7	1	4	2
	1	1	3
Week 8	1	4	3
	1	1	3
Week 9	1	2	3
	1	1	3
Week 10	1	1	3
	1	2	3
Week 11	1	2	3
	1	3	3
Week 12	1	3	3
	1	4	3
Week 13	1	3	3
	1	4	3

4g Dance performance compared between pre- and post-intervention

Number	Items	Intervention group (n=67)			Pre- vs post-intervention (all 10-item combined) **p-value**
		Pre-intervention	Post-intervention	Pre vs post-p-value	
1	Coordination	7.85 ± 0.78	7.97 ± 0.80	0.364	0.167
2	Control of movement	7.85 ± 1.02	7.95 ± 0.81	0.459	
3	Spatial awareness	7.62 ± 0.91	7.82 ± 0.88	0.170	
4	Accuracy of movement	7.86 ± 0.85	8.04 ± 0.91	0.229	
5	Skill level (virtuosity)	7.68 ± 1.01	7.93 ± 0.85	0.142	
6	Timing and rhythmical accuracy	7.85 ± 0.76	7.86 ± 0.80	0.972	
7	Response to phrasing and dynamics	7.60 ± 0.94	7.78 ± 0.82	0.215	
8	Expression and interpretation	7.85 ± 0.90	7.90 ± 1.01	0.624	
9	Communication/projection	7.88 ± 0.96	7.96 ± 1.05	0.795	
10	"X-factor"	7.83 ± 0.96	7.90 ± 1.03	0.722	

Please note that † means $p<0.05$ and ‡ means $p<0.001$

13. Publications

1 Dang Y, Koutedakis Y, Chen R, Wyon MA. Prevalence and risk factors of dance injury during COVID-19: a cross-sectional study from university students in China. *Frontiers in psychology.* 2021;12:759413.

2 Dang Y, Chen R, Koutedakis Y, Wyon MA. The Efficacy of Physical Fitness Training on Dance Injury: A Systematic Review. *International Journal of Sports Medicine.* 2023;44(02): 108-116.

3 Dang Y, Koutedakis Y, Chen R, Wyon M. Online Dance Injury Monitoring: The Efficacy of Weekly Reporting and Respondent Compliance Over a 30-Week Period. *Journal of Dance Medicine & Science.* 2022:1089313X231177172.

4 Dang Y, Koutedakis Y, Chen R, Wyon M. Injury incidence and Severity in Chinese pre-professional dancers: a prospective weekly monitoring survey. *Journal of Science and Medicine in Sport.* 2023.

5 Dang Y, Niemz N, Koutedakis Y, Chen R, Wyon M. <The efficacy of strength and conditioning training on dance injury, physical fitness and dance performance in Chinese pre-professional dancers>, *European Journal of Sport Sciences.* 2023; Accepted.