UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Injury, illness and physical demands of professional contemporary dancers: Health outcomes and methodological issues

by Annie Caroline Jeffries

Thesis submitted in fulfilment of the requirements for
the degree of

Doctor of Philosophy

Under the supervision of
Professor Franco Impellizzeri
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Certificate of Authorship and Originality of Thesis

I, Annie Jeffries declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the school of Sport, Exercise & Rehabilitation, Faculty of Health at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Preface

This thesis for the degree of Doctor of Philosophy is in the format of published or submitted manuscripts and abides by the 'Procedures for Presentation and Submission of Theses for Higher Degrees – University of Technology Sydney; Policies and Directions of the University'.

Based on the research design and data collected by the candidate two manuscripts have been published and two manuscripts are currently under review in peer reviewed journals. These papers are firstly brought together by an *Introduction*, which provides background information, an explanation of the research problem and the aims of the series of studies. A *Literature Review* then follows with an overview of health-related issues and measures in professional dance including injury, illness and training load, highlighting the gaps within the literature. The body of the research in this thesis is then presented in manuscript form, in a sequence following the development of research ideas in this investigation. As such, each manuscript outlines and discusses the individual methodology and the findings of each study separately. These chapters are formatted according to the specific journal requirements and therefore may slightly vary from each other. The *General Discussion* chapter provides an interpretation of the collective findings and practical applications from the series of investigations conducted. The *Summary* chapter incorporates the flow of research ideas and conclusions from each project and outlines directions for future research.

List of manuscripts submitted for publication

Jeffries, A.C., Wallace, L., Coutts, A.J., Cohen, A.M., McCall, A., Impellizzeri, F.M. (2020). Injury, Illness, and Training Load in a Professional Contemporary Dance Company: A Prospective Study. *Journal of Athletic Training*. 55(9), 967–976.

Jeffries, A.C., Wallace, L., Coutts, A.J., McLaren, S.J., McCall, A., & Impellizzeri, F.M. (2020). Athlete-Reported Outcome Measures for Monitoring Training Responses: A Systematic Review of Risk of Bias and Measurement Property Quality According to the COSMIN Guidelines. *International Journal of Sports Physiology and Performance*. 15 (9), 1203-1215.

Jeffries, A.C., Marcora, S., Coutts, A. J., Wallace, L., McCall, A., & Impellizzeri, F. M. Development of a revised conceptual framework of physical training for measurement validation and other applications. *Sports Medicine* [under revision, minor modifications requested].

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Conference proceedings

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Statement of candidate contribution

Table 1. 1: Percentage contribution of authors to peer-reviewed manuscripts of thesis

Author	Study One (Chapter Three)					
	Annie Jeffries	**Lee Wallace**	**Aaron Coutts**	**Ashlea Cohen**	**Alan McCall**	**Franco Impellizzeri**
Research design	60%					40%
Ethics application	90%		10%			
Subject recruitment	80%			20%		
Data collection	70%			30%		
Data cleaning	100%					
Statistical analysis	70%					30%
Manuscript preparation	100%					
Manuscript revision	40%	5%	10%		10%	35%

Author	Study Two (Chapter Four)					
	Annie Jeffries	**Lee Wallace**	**Aaron Coutts**	**Shaun McLaren**	**Alan McCall**	**Franco Impellizzeri**
Research design	60%					40%
Ethics application						
Subject recruitment						
Data collection	70%	20%				10%
Data cleaning	80%					20%
Statistical analysis	90%					10%
Manuscript preparation	100%					
Manuscript revision	40%	5%	10%	15%	10%	20%

Author	Study Three (Chapter Five)					
	Annie Jeffries	**Samuele Marcora**	**Aaron Coutts**	**Lee Wallace**	**Alan McCall**	**Franco Impellizzeri**
Research design	40%	20%				40%
Ethics application						
Subject recruitment						
Data collection	60%					40%
Data cleaning						
Statistical analysis						
Manuscript preparation	100%					
Manuscript revision	20%	25%	10%	5%	10%	30%

Author	Study Four (Chapter Six)					
	Annie Jeffries	**Andrew Novak**	**Aaron Coutts**	**Alan McCall**	**Shaun McLaren**	**Franco Impellizzeri**
Research design	60%					40%
Ethics application	90%					10%
Subject recruitment	90%					10%
Data collection	100%					
Data cleaning	100%					
Statistical analysis	50%	20%				30%
Manuscript preparation	100%					
Manuscript revision	30%	10%	10%	10%	10%	30%

Abstract

Introduction: Professional dance is a highly demanding physical activity, with both high injury rates and training load and no research examining illness occurrence. Additionally, few studies have investigated these relationships concurrently. In order to investigate relationships conceptual models and valid measurement tools are required. Despite the widespread use of these measurement tools few have been validated. Therefore, this thesis sought to investigate training load, injury and illness in dance and also develop an appropriate conceptual framework for monitoring and also validating measurement tools in dance. In *Study One*, medical attention and time loss injury, illness and training load data were recorded across one year in a cohort of professional contemporary dancers (n=16). The results show that professional dancers experienced high training loads relative to other athletes and concomitantly high injury and illness incidences and risks. In addition, dancers continued training and performing, even when affected by medical attention injury or illness. *Study Two* was a two-part systematic review. Part one identified the most commonly used athlete reported outcome measures (AROMs) in sport for monitoring training responses; part two assessed the risk of bias, measurement properties, and level of evidence, based on international clinimetric guidelines. Results demonstrated that whilst the measurement properties of multiple-item AROMs derived from psychometrics were acceptable (with the exclusion of content validity and measurement error) the single-item AROMs most frequently used in sport science have not been validated. Until proper validation studies are completed, all conclusions based on these AROMs are questionable. *Study Three* was the development of an updated conceptual framework providing an overarching model that may help understand and guide the development, validation, implementation, and interpretation of measures used for athlete monitoring. Using the conceptual framework (*Study Three*) as a foundation, *Study Four*

examined the construct validity and reliability of the single items fatigue and recovery for measuring the training effects in dancers. Results provide preliminary evidence confirming the construct validity, reliability and agreement for the single item of fatigue. The recovery item, despite acceptable reliability and agreement, was only partially confirmed in terms of construct validity, when using the SRSS recovery items as reference. *Conclusion:* Collectively, this thesis provides novel information regarding factors affecting dancer's health and the development of a conceptual framework for monitoring and also validating measurement tools in dance.

Keywords

Rating of perceived exertion

Upper respiratory tract infection

Injury surveillance

Measurement properties

Training effects

Performance

Subjective measures

Athlete monitoring

Fatigue

Recovery

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List of Abbreviations

Absolute	unipolar scale
ABQ	athlete burnout questionnaire
ACSM	American college of sports medicine
ARSS	acute recovery stress scale
AROM	athlete reported outcome measure
AU	arbitrary units
BRUMS	Brunel Mood Scale
CK	creatine kinase
CI	confidence interval
CMJ	countermovement jump
COSMIN	COnsensus-based Standards for the selection of health Measurement Instruments
COVID-19	corona virus disease of 2019
CR-10	category ratio
DALDA	daily analysis of life demands for athletes
DOMS	delayed-onset muscle soreness
ECSS	European college of sport science
Fatigue ABS	fatigue absolute
Fatigue REL	fatigue relative
GPS	global positioning system
HREC	human research ethics committee
H	hours
HRV	heart rate variability
IQR	inter quartile range
IR	impulse-response
LW	linearly weighted
Med-Inj	medical attention injury
Neg.emo.state	negative emotional state
Mental perf	mental performance
MTDS	multi-component training distress scale
NIH	national institute of health

No	number
OFSM	overtraining questionnaire of the societe francaise de medecine du sport
Overall recov	overall recovery
PerPot	Performance potential metamodel
Physical perf	physical performance
POMS	Profile of mood state
PRISMA	Preferred Reporting Items for Systematic Review and Meta-Analysis
PROMIS	Patient-Reported Outcomes Measurement Information System
PRSS	Perceived recovery stress scale
PSS	perceived stress scale
REDCap	research electronic data capture
Recov ABS	recovery absolute
Recov REL	recovery relative
Relative	bipolar scale
RESTQ-Sport	Recovery-stress questionnaire athletes
SI	single item
SRSS	Short recovery and stress scale
SRSS Recov	Short recovery and stress scale recovery
SD	standard deviation
sRPE	session rating of perceived exertion
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
Tim-Inj	time loss injury
TQR	Total quality recovery scale
TL	training load
URTI	upper respiratory tract infection
y	years