Fifth Edition

Sport and Exercise Physiology Testing Guidelines: Volume I – Sport Testing

The British Association of Sport and Exercise Sciences Guide

Edited by R. C. Richard Davison, Paul M. Smith, James Hopker, Michael J. Price, Florentina Hettinga, Garry Tew, and Lindsay Bottoms

Sport and Exercise Physiology Testing Guidelines: Volume I – Sport Testing

Since its first published edition more than 30 years ago, the BASES (British Association of Sport and Exercise Sciences) Physiological Testing Guidelines have represented the leading knowledge base of current testing methodology for sport and exercise scientists. Sport and exercise physiologists conduct physiological assessments that have proven validity and reliability, both in laboratory and sport-specific contexts. A wide variety of test protocols have been developed, adapted and refined to support athletes of all abilities reach their full potential. This book is a comprehensive guide to these protocols and to the key issues relating to physiological testing.

With contributions from leading specialist sport physiologists and covering a wide range of mainstream sports in terms of ethical, practical and methodological issues, this volume represents an essential resource for sport-specific exercise testing in both research and applied settings. This new edition draws on the authors' experience of supporting athletes from many sports through several Olympic cycles to achieve world leading performances. While drawing on previous editions, it is presented in a revised format matching the sport groupings used in elite sport support within the UK sport institutes. Building on the underpinning general procedures, these specific chapters are supported by appropriate up-to-date case studies in the supporting web resources.

R. C. Richard Davison, PhD, FBASES, CSci, is Professor of Exercise Physiology in the School of Health and Life Sciences at the University of the West of Scotland, UK.

Paul M. Smith, PhD, FBASES, FHEA, is Senior Lecturer in Exercise Physiology in the School of Sport and Health Sciences at Cardiff Metropolitan University, UK.

James Hopker, PhD, is Professor of Sport and Exercise Science and Deputy Director of the Division of Natural Sciences at the University of Kent, UK.

Michael J. Price, PhD, FBASES, is Reader in Exercise Physiology at Coventry University, UK.

Florentina Hettinga, PhD, FACSM, FECSS, SFHEA, is Professor of Sport, Exercise and Rehabilitation at Northumbria University, UK.

Garry Tew, PhD, FBASES, FHEA, is Professor of Clinical Exercise Science in the Department of Sport, Exercise and Rehabilitation at Northumbria University, UK.

Lindsay Bottoms, PhD, FBASES, is Reader in Exercise and Health Physiology at the University of Hertfordshire, UK and the Director of the Research Centre for Psychology and Sports Sciences.

Sport and Exercise Physiology Testing Guidelines: Volume I – Sport Testing

The British Association of Sport and Exercise Sciences Guide

Fifth Edition

Edited by R. C. Richard Davison, Paul M. Smith, James Hopker, Michael J. Price, Florentina Hettinga, Garry Tew, and Lindsay Bottoms

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

BASES
The British Association of Sport and Exercise Sciences

Cover image: © metamorworks/Getty Images

Fifth edition published 2022
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

and by Routledge
605 Third Avenue, New York, NY 10158

Routledge is an imprint of the Taylor & Francis Group, an informa business

First edition published by BASES 1988
Fourth edition published by Routledge 2009

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data
A catalog record for this book has been requested

ISBN: 978-0-367-49246-5 (hbk)
ISBN: 978-0-367-49133-8 (pbk)
ISBN: 978-1-003-04528-1 (ebk)

DOI: 10.4324/9781003045281

Typeset in Baskerville
by Apex CoVantage, LLC

Access the Support Material: www.routledge.com/9780367491338

Contents

Figures

Tables

Contributors

Liam Anderson
University of Birmingham, UK

Paul Ansdell
Northumbria University, UK

Chris Barnes
CB Sports Performance Ltd, UK

Lee Bell
Sheffield Hallam University, UK

Steve R. Bird
Royal Melbourne Institute of Technology, Australia

Nicolette C. Bishop
Loughborough University, UK

Matthew I. Black
University of Exeter, UK

Lindsay Bottoms
University of Hertfordshire, UK

Craig A. Bridge
Edge Hill University, UK

Georgie Bruinvels
St Mary's University, UK

John Buckley
University of Chester, UK

Mark Burnley
University of Kent, UK

Jan Burns
Canterbury Christ Church University, UK

Adrian Campbell
SportScotland Institute of Sport, UK

Dale Cannavan
Seattle Pacific University, USA

Robert Cawdron
British Fencing, UK

Helen M. Collins
University of Dundee, UK

Aaron J. Coutts
University of Technology, Sydney, Australia

R. C. Richard Davison
University of the West of Scotland, UK

Marlize de Vivo
Canterbury Christ Church University, UK

Anne Delextrat
Oxford Brookes University, UK

Terun Desai
University of Hertfordshire, UK

John Dickinson
University of Kent, UK

Michael Dooley
The Poundbury Clinic Dorset & King Edward VII Hospital London, UK

Barry Drust
University of Birmingham, UK

Audrey Duncan
University of Dundee, UK

Mike Duncan
Coventry University, UK

Clare Eglin
University of Portsmouth, UK

Stuart Elwell
Dudley Physiotherapy Clinic, UK

Roger Eston
University of South Australia, Australia

Irene R. Faber
International Table Tennis Federation, Switzerland, and Carl von Ossietzky University, Germany

Richard A. Ferguson
Loughborough University, UK

Lin Foo
Imperial College London, UK

Emerson Franchini
University of São Paulo, Brazil

Simon Fryer
University of Gloucestershire, UK

Edward Gibson-Smith
Sheffield Hallam University, UK

Sarah Gilchrist
Gilchrist Performance, UK

David Giles
University of Derby, UK

Olivier Girard
The University of Western Australia, Australia

Richard J. Godfrey
Brunel University, UK

Stuart Goodall
Northumbria University, UK

Vicky L. Goosey-Tolfrey
Loughborough University, UK

Richie P. Goulding
Kobe Design University, UK

David Green
English Institute of Sport, UK

Luke Gupta
English Institute of Sport, UK

Anthony C. Hackney
University of North Carolina, USA

Brian Hanley
Leeds Beckett University, UK

Amal Hassan
University College Healthcare NHS Trust and University College London, UK

Florentina J. Hettinga
Northumbria University, UK

Andrew Hext
Sheffield Hallam University, UK

Kirsty M. Hicks
Northumbria University, UK

Jamie Highton
University of Chester, UK

Karen Hind
Durham University, UK

Mark Homer
Buckinghamshire New University, UK

James G. Hopker
University of Kent, UK

Glyn Howatson
Northumbria University, UK

Andy Howse
Basketball England, UK

Michael Hutchinson
English Institute of Sport, Loughborough University, UK

Franco M. Impellizzeri
University of Technology, Australia

Carl A. James
National Sports Institute, Malaysia

Monèm Jemni
Hartpury University, UK

Simon Jobson
University of Winchester, UK

Thomas W. Jones
Northumbria University, UK

Timothy Jones
Institut Sukan Negara (National Sports Institute), Malaysia

Emma Kavanagh
Bournemouth University, UK

Steve Kemp
British Fencing, UK

Mohammed Khudair
Northumbria University, UK

Christoph Lees
Imperial College London, UK

David Leith
British Curling, UK

Susan C. Lennie
Newcastle University, UK

Clare Lobb
Sport Scotland Institute of Sport, UK

Mitch Lomax
University of Portsmouth, UK

Rachel N. Lord
Cardiff Metropolitan University, UK

Mark Lyons
University of Limerick, Ireland

Hannah MacLeod
Great Britain Hockey, Track Record, UK

Caroline MacManus
High Performance Sport, New Zealand

Kelly Marrin
Edge Hill University, UK

Simon Marwood
Liverpool Hope University, UK

Heather Massey
University of Portsmouth, UK

Ronald J. Maughan
St Andrews University, UK

Neil S. Maxwell
University of Brighton, UK

Kerry McGawley
Mid Sweden University, Sweden

Pete McKnight
Hintsa Performance, UK

Shaun J. McLaren
Durham University, UK

Melitta McNarry
Swansea University, UK

Victoria L. Meah
University of Alberta, Canada

Andrew M. Miles
Cardiff Metropolitan University, UK

Goran Munivrana
University of Split, International Table Tennis Federation, Switzerland

Martha Brouwer Muñoz
Vrije Universiteit Amsterdam, Netherlands

Connor Murphy
Loughborough University, UK

Laura Needham
English Institute of Sport, UK

Emma Neupert
University of Portsmouth, UK

Mark Noon
Coventry University, UK

John Noonan
Hintsa Performance, UK

Luke Oates
Middlesex University, UK

Tom O'Brien
Loughborough University, UK

Cameron Owen
Leeds Beckett University and Leeds Rhinos Netball, UK

David Oxborough
Liverpool John Moores University, UK

Charles R. Pedlar
St Mary's University, UK

Michael J. Price
Coventry University, UK

Mayur Ranchordas
Sheffield Hallam University, UK

Daniel Rhind
University of Loughborough, UK

Alan Ruddock
Sheffield Hallam University, UK

Benjamin E. Scott
English Institute of Sport, University of Brighton, UK

Andy Shaw
English Institute of Sport, UK

Susan M. Shirreffs
St Andrews University, UK

Natalie F. Shur
University of Nottingham, UK

Len Parker Simpson
Japan Cycling, Japan

Ciara Sinnott-O'Connor
Sport Ireland Institute, Ireland

Andrew Smith
Former BASES Chair, UK (retired)

Mark F. Smith
University of Lincoln, UK

Paul M. Smith
Cardiff Metropolitan University, UK

S. Andy Sparks
Edge Hill University, UK

Mike Stembridge
Cardiff Metropolitan University, UK

Ben Stephenson
English Institute of Sport, Loughborough University, UK

Caroline Sunderland
Nottingham Trent University, UK

Karl Sylvester
Cambridge University Hospitals NHS Foundation Trust, UK

Jamie Tallent
St Mary's University, UK

Kevin Thomas
Northumbria University, UK

Katie Thralls Butte
Seattle Pacific University, USA

Michael Tipton
University of Portsmouth, UK

Keith Tolfrey
Loughborough University, UK

Craig Twist
University of Chester, UK

Will Vickery
Deakin University, Australia

Kyle Wallace
Ulster University, UK

Neil P. Walsh
Liverpool John Moores University, UK

Matthew Weston
Teeside University, UK

Sarah Whitehead
Leeds Beckett University and Leeds Rhinos Netball, UK

Craig A. Williams
University of Exeter, UK

Mark Williams
Basketball England, UK

Ash G. B. Willmott
Anglia Ruskin University, UK

Edward Winter
Sheffield Hallam University, UK

Foreword

I write this foreword as the current and first female chair of the British Association of Sport and Exercise Sciences and am delighted to offer support for these Exercise Testing Guidelines. These separate textbooks epitomise the work of the association, through professional collaboration, keeping BASES at the forefront of world-leading science and achieving considerable reach and impact.

The clear expansion of the textbooks, evidenced by overall scale, variety and quality of content, as well as the number and diversity of contributors, is commendable. The contributors are highly respected academics and/or practitioners (many of whom are BASES fellows), and many have collaborated with emerging, early career colleagues. The quality of these textbooks, combined with the process employed by contributors and the editorial team, reflects a commitment to ensure that the standards for sport and clinical physiological testing remains exemplary. This timely project has produced a model of excellent practice, which other disciplines may consider emulating in the future.

Professor Zoe Knowles FBASES, FHEA,
HCPC Practitioner Psychologist
BASES Chair
Liverpool John Moores University, UK

*****

I write as a two-time and first chair of BASES and commend the editors and authors on the completion of the latest edition of the Exercise Testing Guidelines. This new edition is a true reflection on the development of BASES and the profession since the very first Physiological Testing Guidelines were produced in 1986. In the first edition the authors produced recommendations that provided the foundations for 'best practice' for physiological testing of athletes. Before its publication there was no consensus on testing methodologies and often scant regard for the principles of scientific rigour.

Over the ensuing 35 years, each subsequent edition has extended the range of topics and addressed new challenges without compromising the principles of scientific rigour and relevance. In this new edition, the coverage and depth of information are again a significant step forward, providing an exceptional resource

for sport and exercise physiologists, particularly for those progressing towards BASES accreditation. This series of guidelines has helped establish and consolidate the association's reputation as a world leader for physiological testing in health and disease. Therefore, it is with great pride and gratitude that I commend the new Exercise Testing Guidelines to all who study, teach and research in sport and exercise sciences.

Professor Clyde Williams OBE, DSc, PhD, FBASES, FFSEM
Professor of Sports Science (emeritus)
Loughborough University, UK

Introduction

R. C. Richard Davison and Paul M. Smith

The origins of the BASES Physiological Testing Guidelines date back to 1986, when the Sports Physiology Section of the British Association of Sports Sciences (BASS) created a working group of Neil Armstrong, Adrianne Hardman, Philip Jakeman, Craig Sharp and Edward Winter. Together, they produced a BASS Position Statement on the Physiological Assessment of the Elite Competitor (Hale et al., 1988). As the study of sport science began to grow, BASS established accreditation schemes for individual practitioners and exercise testing laboratories. In 1998, a second edition of the exercise testing guidelines made reference to both accreditation schemes.

Some nine years later, BASS had evolved into the British Association of Sport and Exercise Sciences (BASES) to acknowledge that not all exercise scientists were exclusively interested in sport. In 1997, Steve R. Bird and R. C. Richard Davison took over the responsibility of editing the third edition of the BASES 'Physiological Testing Guidelines'. This consisted of 19 chapters organised in four sections: General issues and procedures; Generic testing procedures; Sport-specific testing guidelines; and Specific considerations for the assessment of the young athlete (Bird and Davison, 1997).

A further gap of ten years elapsed before the fourth edition was published in 2006 (Winter et al., 2006a, 2006b), and this represented a significant expansion of the coverage of the guidelines, resulting in two volumes: one with an emphasis on sport, while the other focused on clinical practices. Although both volumes shared chapters linked to common principles of physiological exercise testing, remaining chapters related to either sport or clinical topics. The expansion and creation of distinct textbook volumes reflected the growing number of BASES members and accredited practitioners in respective areas.

Since the last edition the number of students studying sport and exercise science in the UK has continued to grow, with more than 17,500 students accepted on to a sport and exercise science course in 2018/19. At that time, the total number of students studying a higher education course in the UK related to sport and exercise science was just under 49,000 and continues to grow. Mirroring this growth has been the increase in vocational applications of sport and exercise science, and many enjoy careers in diverse settings. These settings include sport and exercise support work with national governing bodies, professional clubs, the

DOI: 10.4324/9781003045281-1

Home Countries' Sport Institutes and public and private healthcare providers. Employment opportunities also exist in private enterprises, governmental, voluntary and local authority organisations engaged in the provision of exercise and physical activity for people with or at high risk of developing a myriad of diseases and associated disabilities.

In line with this significant increase of student numbers and applied professions has been the expansion of research in the sport and exercise sciences, which now provides a significantly expanded evidence base that underpins the physiological assessments in the current two volumes.

This edition provides a reference guide for sport and exercise scientists in training (BASES supervised experience), practitioners, researchers and teachers in sport and exercise science. During very challenging times, members of the editorial team have worked with a wide range of contributors, including many of the United Kingdom's leading sport and exercise scientists and/or practitioners. The two volumes of the BASES Exercise Testing Guidelines provide a comprehensive resource, which is underpinned by the latest research and practice in elite sport and the clinical sciences.

Sadly, since 2006, we have lost several giants of our discipline, who were authors/editors of previous editions: Craig Sharp, Tom Reilly and Edward Winter. Each of these individuals were passionate about BASES and the development of the subject area to whom we owe a great debt.

We would like to pay a particular tribute to Edward Winter, who led the editorial team for the last edition and has contributed to every edition of the guidelines, including a chapter in this edition that was completed before his death.

References

Bird, S. and Davison, R. C. R. (1997). *Physiological Testing Guidelines* (3rd ed.). Leeds: The British Association of Sport and Exercise Sciences.

Hale, T., Armstrong, N., Hardman, A., Jakeman, P., Sharp, C. and Winter, E. (1988). *Position Statement on the Physiological Assessment of the Elite Competitor* (2nd ed.). Leeds: White Line Press.

Winter, E. M., Jones, A. M., Davison, R. C. R., Bromley, P. D. and Mercer, T. (2006a). *Sport and Exercise Physiology Testing Guidelines: Volume I: Sport Testing: The British Association of Sport and Exercise Sciences Guide*. Abingdon, UK: Routledge.

Winter, E. M., Jones, A. M., Davison, R. C. R., Bromley, P. D. and Mercer, T. (2006b). *Sport and Exercise Physiology Testing Guidelines: Volume 2: Clinical Testing: The British Association of Sport and Exercise Sciences Guide*. Abingdon, UK: Routledge.

Part I

Professional best practice

1.1 Professional competency and working with others

Michael J. Price, Andrew M. Miles, and Paul M. Smith

Introduction

Achieving and maintaining a *minimum standard of professional competency* is an important aspect of many careers, and sport and exercise science is no exception. Careers such as medicine, nursing and physiotherapy require practitioners to record and evidence their ongoing professional development, and the relevant professional bodies conduct regular audits in order for practitioners to retain their registration. Whilst BASES does not currently require ongoing evidence of continued development, it does have a strong ethos of achieving and maintaining high standards and professional development, as evidenced in its accreditation and re-accreditation pathways. These require practitioners to meet minimum standards to achieve initial accreditation and to evidence continued professional development and sustained growth to secure re-accreditation.

Within the UK, whether as part of a research role, clinical (or sport) service provision or learning and teaching sport and exercise science, practitioners must abide by the BASES Code of Conduct. This code encompasses specific elements of research ethics, personal and professional conduct and competence. Indeed, there are many linked chapters within this textbook, which relate to these specific issues to help you ensure your practice is consistent with good practice.

Members, at all times, must have regard for the following principles:

a) all Clients have the right to expect the highest standards of professionalism, consideration and respect.
b) the pursuit of scientific knowledge requires that research and testing is carried out with utmost integrity.
c) the law requires that working practices are safe, that the welfare of the Client is paramount, and that data is used and stored in accordance with the law.

BASES Code of Conduct (Paragraph 4.3) March 2017

NB: In anticipation of the publication date of this textbook, note that the BASES code of conduct is currently under review, with a new version available by early 2022.

DOI: 10.4324/9781003045281-3

Maintaining and extending professional competency

The premise underpinning professional competency suggests that an individual achieves some initial baseline, or minimum threshold standard in the form of a measure of his or her '*fitness to practice'* or a '*license to practice*'. In some professions, this criterion requirement is associated with formal, professional body–endorsed academic training at either the undergraduate or postgraduate level (e.g., British Association of Sport Rehabilitators and Trainers [BASRaT]). In other professions, demonstration of professional competency may be attached to evidencing competence through professional practice or training after graduation to achieve professional body recognition through an *accreditation scheme* or similar (e.g., BASES or British Psychological Society). Having achieved this initial baseline, there is an expectation that practitioners maintain and extend their competency and knowledge base through ongoing training and continuous professional development. An employer, a professional organisation and/or private providers can provide ongoing training. Responsibility for maintaining and extending competence lies with the practitioner, but is typically regulated or mandated by the profession.

Employers require minimum knowledge and standards, often identified as 'essential' or 'desirable' skills and knowledge, within person specifications and job descriptions. Many identify that a candidate or applicant must have professional body endorsement/accreditation or similar. This is imperative and ensures an employee can 'hit the ground running' with the minimum acceptable professional knowledge and skills. By ensuring recruits have the required professional skillsets at the outset, employers can focus any initial induction on job- and employer-specific training such as health and safety, data handling and internal policies and practices, some of which are included in chapters of this textbook immediately following this.

Safeguarding and welfare are relevant in all contexts of a client-based industry, but special consideration is required when working with either young or vulnerable populations. In the UK, anyone working with minors (i.e., participants under 18 years of age) or vulnerable groups (e.g., clinical patients or some individuals with physical and/or learning disabilities) must gain formal clearance through the disclosure and barring service (DBS). Sport and exercise practitioners should thus be aware and informed of such areas, referring to policies of their own organisation, BASES's governance documents or policy documents (e.g., Safeguarding and Welfare Policy). In the context of applied sport and exercise science practices, we also refer readers to a wealth of sport- and exercise science–specific information and applied recommendations within a repository of BASES Expert Statements.

Once a practitioner is 'skilled' in both a professional and internal organisational capacity, she or he then needs to *remain up-to-date on emerging developments* in both contexts. There is a shared responsibility between the employer, the profession and an individual to ensure that practitioners are able to access continued professional development (CPD) opportunities. As alluded to earlier, employers and practitioners should be proactive in seeking training opportunities which

extend beyond compulsory in-house requirements. Practitioners should be able to clearly demonstrate the retention of their 'fitness to practise' through accessing CPD opportunities such as external (professional) training events, conferences, peer-reviewed publications and opportunities to shadow/observe other practitioners/supervisors, engaging in professional networks and remaining aware of evolving professional regulatory standards. Engagement with a suitable (academic or clinical) mentor (or supervisor) can prove beneficial, helping to ensure a practitioner remains abreast of area-specific requirements, identifying and capitalising upon gainful CPD opportunities.

A fundamental activity to help practitioners recognise those areas of their professional practice in need of improvement is *reflective practice* (Huntley et al., 2019). Reflective practice is a cognitive process that allows practitioners to examine their own professional practice by asking themselves questions about how and why they do things and considering the impact of their actions and decisions on their practice and on the experiences of their clients. Although many reflective practice articles within sport and exercise science appear biased towards sport and exercise psychology (Huntley et al., 2014), reflective practice is key to all applied practice disciplines. However, a study of coach education noted a lack of confidence in understanding reflective practice and thus limited engagement with it (Cropley et al., 2012). Although it is beyond the scope of this chapter to discuss models of reflective practice and the process per se, it is important to note the range of reflective practice models available – each with associated pros and cons (Knowles et al., 2014).

Working in multi- and inter-disciplinary teams

An important requirement in the context of BASES-supervised experience is the consideration and appreciation that working as a component of an integrated, multidisciplinary (or inter-disciplinary) team is a factor that is key for sporting, exercise and health arenas. As a specialist within a particular field of study, you will typically find yourself working alongside others to achieve a common goal, whether evaluating a patient's pre-operative fitness or the impact of a specific intervention on an elite athlete's performance.

Within the sport and exercise sciences, a subtle difference exists between the terms multi- and inter-disciplinarity. With a client at the centre of a wheel (the hub), a multidisciplinary approach would have professions within their individual silos on the rim, all heading towards the centre with no interaction – a parallel provision of support. However, inter-disciplinary work infers there is some interaction between professional areas. For example, a change in sporting equipment and/or technique (i.e., biomechanics), or improvements in strength (i.e., strength and conditioning) might improve exercise efficiency/economy (i.e., exercise physiology), thus leading to an improvement in situation-specific confidence (i.e., training and/or competition) and an improvement in performance. Likewise, in a clinical setting, an improvement in physiological/metabolic fitness and function (i.e., physiology), resulting from behaviour change (i.e., health psychology; see West

et al., 2019) will lead to improved self-efficacy (i.e., psychology), leading to greater independence and improvement in overall quality of life.

Within the clinical sciences, many good examples of the workings of multi- and inter-disciplinary teams exist, but the extent of the literature pertaining to such an approach in the sport and exercise sciences remains somewhat scant. This situation continues despite Burwitz et al. (1994) raising the importance of this approach more than a quarter of a century ago. In the context of the sport and exercise community, some good examples exist of multidisciplinary approaches to the support and preparation of individual elite athletes and/or squads.

There will always be limitations to research endeavours and/or programmes of clinical provision/sport science support. A frequent shortfall is the poor translation of existing knowledge to applied practice. While the concept of 'evidence-based practice' is broadly accepted, a paradox exists where a practitioner may turn to 'practice-based evidence'. To contextualise this point, an example relates to the broad topic of coaching or sport science support of elite athletes. While a vast amount of scientific literature exists for well-trained groups of athletes, little exists for truly elite, international competitors. In this example, Ross et al. (2018) describe a need to adopt a blended approach to the collection and assimilation of knowledge to create often novel and unique solutions and practical applications. Here one might draw on all available knowledge, gaining insight from a scientific, professional experience and anecdotal perspectives.

This chapter provides the reader with a general overview of professional practice, competency and the concept of multi- and inter-disciplinary teams. Your challenge is to seek subject-specialist information to help you become more informed and the most competent and effective practitioner possible. Consulting the considerable array of information contained within the BASES policy documents, guidelines and expert statements is highly recommended.

References

Burwitz, L., Moore, P. M. and Wilkinson, D. M. (1994). Future directions for performance-related sports science research: An interdisciplinary approach. *Journal of Sport Sciences*, 12, 93–109.

Cropley, B., Miles, A. and Peel, J. (2012). Reflective practice: Value of, issues, and developments within sports coaching. Sports Coach UK Original Research.

Huntley, E., Cropley, B., Gilbourne, D., Sparkes, A. and Knowles, Z. (2014). Reflecting back and forwards: An evaluation of peer-reviewed reflective practice research in sport. *Reflective Practice*, 15, 863–876.

Huntley, E., Cropley, B., Knowles, Z. and Miles, A. (2019). BASES expert statement: Reflective practice: The key to experimental learning. *The Sport and Exercise Scientist*, 60(Summer), 6–7.

Knowles, Z., Gilbourne, D., Cropley, B. and Dugdill, L. (2014). *Reflective Practice in the Sport and Exercise Sciences: Contemporary issues*. Edited By Zoe (1st ed.). Abingdon, UK: Routledge.

Ross, E., Gupta, L. and Sanders, L. (2018). When research leads to learning, but not action in high performance sport. In *Progress in Brain Research*, pp. 201–217. (Textbook series Chapter 12).

West, R., Michie, S., Chadwick, P., Atkins, L. and Lorencatto, F. (2019). Achieving behaviour change: A guide for local government and partners. *Public Health England: Protecting and Improving the Nation's Health*. www.gov.uk/government/publications/behaviour-change-guide-for-local-government-and-partners (accessed 12 May 2021).

Useful resources

BASES Code of Conduct. www.bases.org.uk/imgs/bases_code_of_conduct872.pdf

The BASES Expert Statement on Ethics and Participation in Research of Young People (2011). www.bases.org.uk/imgs/ethics_and_participation_in_research_of_young_people625.pdf

BASES Safeguarding and Welfare Policy. https://bases.org.uk/imgs/bases_safeguarding___welfare_policy215.pdf (accessed 21 April 2021).

BASES Safeguarding Statement. www.bases.org.uk/imgs/expert_statement_1__pages_380.pdf (accessed 21 April 2021).

General Data Protection Regulations. www.gov.uk/government/publications/guide-to-the-general-data-protection-regulation (accessed 21 April 2021).

1.2 Physiological exercise testing

Ethical considerations

Steve R. Bird and Andrew Smith

The ethics of physiological testing is an important consideration, whether one is conducting tests for research, sport science support, clinical health assessments or teaching. It is an expectation that BASES members will undertake their work in an ethical manner and adhere to the principles of professional practice. This chapter will consider what this means in the context of physiological testing and provide some guidelines on what considerations one must take to ensure that one conducts physiological testing in an ethical manner.

As regulations and legislation change over time and vary across nations, it is important that readers cross reference this chapter with the frameworks in the place when and where they are testing. It is the responsibility of the sport and exercise scientist to identify what approvals they need and which regulations they must adhere to before commencing any test battery.

The application of ethical principles to physiological testing

In relatively recent times, there has been a cultural shift away from the viewpoint that all-knowing experts perform tests on passive subjects, and instead the activity is now recognised as a partnership between assessors and participants, as well as other potential stakeholders. This is reflected in a change in the terminology from the previous vocabulary of referring to those being tested as 'subjects' and instead to now referring to them as 'participants', which is how they will be referred to throughout this chapter. Likewise, for clarity, those responsible for running tests and collecting data will be referred to as 'assessors' from this point onwards.

This partnership of rights, roles and respect is one of many considerations when determining whether the activity is 'ethical'. Within professional practice the conduct of physiological testing in an ethical manner is an expectation, whether it be in research, sport science support, clinical health or teaching, so the conduct of physiological tests in an ethical manner is a principal concern for everyone undertaking this work, regardless of the setting.

Today, research that involves human participants; human organs, tissues, cells, fluids or other biological material; or human data requires approval by a constituted and recognised human research ethics committee. With human samples,

DOI: 10.4324/9781003045281-4

there are also strict codes of conduct and practices set out by the Human Tissue Authority (www.hta.gov.uk). In this context, for example, UK Higher Education Institutions apply for an HTA licence and are subject to ongoing scrutiny to ensure all registered workers abide by the ethical framework set out.

The purpose of human research ethics committees is to ensure that colleagues conduct research ethically and adhere to key principles. The exact wording may differ between codes, but the following directives encapsulate core principles:

1 *Respect* the participants and others involved in the activity;
2 Be fully *transparent* to ensure that all involved are aware of the objectives of the activity, what the activity entails, how data will be managed and any conflicts of interest and be clear about any risks – large or small;
3 Be scientifically *rigorous* in terms of the methods and protocols used (including the calibration of equipment) to ensure the collection of valid, reliable and accurate data;
4 Only be conducted by people who conform to the highest *professional* standards and who are demonstrably competent assessors holding the appropriate qualifications, certification and insurance;
5 Uphold the highest standards of *honesty* and *integrity*;
6 Put the health and safety of all those involved as the top priority and always act to *minimise any risks;*
7 Ensure proposed research outcomes are *meaningful and purposeful* for participants involved; and
8 *Comply* with legal and other regulatory frameworks, including those of the insurer.

The physiological testing of human participants for other purposes, such as fitness testing for sport or health-related assessments and teaching, should also adhere to these principles, regardless of whether the assessment is physiological, biomechanical, psychological, clinical health or medical. The ethical conduct of these activities not only ensures the protection and minimisation of risk to participants and assessors but also to any organisations linked to the work, as well as determining that the activity is of benefit to the individual and/or wider community.

In a research context, a consideration of the numerous ethics principles of working with human participants is formalised, itemised and clearly communicated through the completion of an ethics application form. A relevant ethics committee will then review the application, and an assessment will be made in accordance with the values and guidelines of the code and culture in which the research is taking place.

These same principles should apply to physiological testing in other contexts, with a constituted panel reviewing the submission and providing feedback to the assessors – without such approval, the physiological testing must not proceed. These formalised procedures and the input from a group with diverse experiences will ensure that the proposed physiological testing activity is undertaken in compliance with recognised ethics requirements and, in doing so, will help to safeguard

all involved – participants, assessors, professional organisations and institutions. Forms for physiological testing in 'non-research' contexts can be developed and used to help prevent unethical practice, avoid adverse events and reduce the frequency of complaints, all of which may have detrimental consequences to the participant, assessors, employers of assessors and others.

Where physiological or other testing activity is approved, it is then beholden upon the assessors to comply with the approved procedures and to not deviate from the approved procedures or undertake testing that differs from the approved details. Where there be a need to make subsequent changes, a relevant person, such as the chief investigator (CI) must apply to the relevant ethics committee for an amendment to the previously approved physiological testing activity.

This chapter will deal with the broad principles of ethics for physiological testing, regardless of its context, and highlight any specific issues relating to sport and/or clinical exercise testing as they arise.

Ethical issues relating to physiological testing

The following paragraphs consider some of the ethical issues that the assessor needs to address when planning to undertake physiological testing.

Why are you testing: do foreseen benefits outweigh the risks?

Before undertaking any physiological testing, it is important to weigh up the risks versus likely benefits. To do this, the person responsible for the testing, such as the CI in a research study, or the head of sport and sciences services or the clinical expert in the health field, needs to make explicit the purpose of the testing and, from this, the benefit that would be derived from the findings. In some cases, these benefits will directly affect the participant, such as identifying a health concern or generating a fitness profile to inform their training programme. In other circumstances – indeed in the case of most research – the findings may be of little or no immediate benefit to the research participant, but will contribute to knowledge that, when published, may benefit others.

An assessor must consider likely benefits against potential risks for any participant and, in some cases, the assessor(s) and/or their institution or employing organisation. Assessors can view certain risks as being 'negligible' or 'carrying low risk', such as inconvenience and the investment in time by participants, through to discomfort. Other risks may be categorised as 'more than low risk', such as the risk of distress, physical injury or psychological harm. In research, it is the responsibility of the CI to weigh the merits of the potential benefits against the potential risks. At this stage, if intending to proceed, a relevant ethics committee should consider a formal application. At this point, the ethics committee may ask the CI to provide further clarification or to consider alternative approaches in order to reduce risk. In non-research assessments, other suitable experts within the organisation may fulfil this role if there is no formalised procedure or advisory committee.

Minimisation of risk

Assessors can minimise risk through careful consideration of the intended procedures. These include aspects relating to the participant, the assessors, the exercise protocol, the equipment, the environment and the inclusion of specific safety measures.

- To minimise risks, participants should be screened for contraindications to the exercise or other assessment that they will be asked to undertake, typically using a validated screening tool.
- Those conducting the assessment must be appropriately qualified and have the relevant expertise in the techniques they are using, as well as possessing suitable qualifications in first aid and cardiopulmonary resuscitation (CPR). Furthermore, the assessors should know the appropriate way to respond in the case of any 'adverse event'. It is highly recommended that all assessors complete some form of basic ethics awareness training.
- The protocols used in the testing need to be justified and ideally supported by evidence from previously published work that they are safe, valid and reliable, since collecting data that are not valid or reliable may be deemed unethical, as this wastes the participants' time. Many testing protocols will have elements of safety built in, such as the inclusion of electrocardiographic (ECG) monitoring for some forms of exercise and participant groups, or use of a harness if exercising maximally on a treadmill.
- Additionally, assessors must adhere to safety procedures for cleaning and sterilising equipment. Electrical equipment used must have undergone relevant safety checks, including electrical tests, which will generate safety certificates as required by the work environment.
- For the safety of participants and assessors, appropriate personal protective equipment (PPE) should be worn, which, depending on the nature of the testing, may include protective gloves, laboratory coats, safety glasses, masks and other items.

Any potential risks associated with testing procedures need to be articulated clearly to the participant, usually as part of a clear and detailed 'Participant Information Sheet' (PIS) and associated 'Informed Consent Form' (ICF). This ensures participants are appropriately informed and can thereby provide genuine informed consent for their participation.

Recruitment and power relationships

When undertaking physiological testing as part of a research study, there is usually a clear process of recruitment. This may range from a broad advertisement to the general population to a specific targeting of individuals with specific characteristics, such as particular sporting expertise or health condition. In such circumstances, those volunteering to participate are clearly volunteers who have responded to an advertisement without any inherent obligation to do so. However,

when undertaking fitness testing for a team or squad, the extent of 'volunteerism' may be compromised if it is the coach or manager who deems that all members of a squad should undergo fitness testing. In such cases, the assessor needs to consider very carefully their involvement and whether participation is truly voluntary. A scenario within many professional teams is that the requirement to participate in such activities is part of the participants' contracts, and the assessor needs to consider these issues carefully. In a clinical exercise testing context, the assessor has to be aware of the potential power balance that may exist if the potential participant's doctor, physiotherapist, allied health therapist or pharmacist is involved in the recruitment process. Their involvement in recruitment does not make this process unethical, *per se,* but some scrutiny and careful consideration of how they are involved is required.

Other unbalanced power relationships may exist between university staff and their students, whereby it is important that there should be no perceived obligation for a student to participate in a research study conducted by one of their lecturers. It should be clear that a student's professional relationship with the lecturer and the institution remain unaffected, whether they volunteered or declined to participate. In the context of teaching, those responsible for the physiological testing within academic courses need to carefully consider the ethics of proposed testing, which is likely to involve justifying the inclusion of physiological testing as part of the educational experience. This should always be for the students' benefit of developing their knowledge, understanding, relevant practical skills and awareness through personal experience, but tutors need to consider this matter in light of the students' rights and possible risks.

Power relationships can also influence safeguarding aspects of physiological testing, covered in Chapter 1.4.

Information, consent and the capacity to provide consent or assent (children)

Before participating in any data collection, an assessor must inform all participants of testing procedures and objectives. Participants should know what they will be required to do, how much time may be involved and what, if any, risks they will encounter. Assessors should declare any sources of funding, as a prospective participant may have concerns about potential conflicts of interest. The information given to the participant should also include how the data will be stored securely and who will have access to stored data. This may include the participant, assessor, coach or health/medical practitioner, as well as the intention to publish (usually anonymised group data or de-identified data) in research publications or reports. Regardless of the final intentions of the use of the data, the participant needs to be made aware of this. Additionally, the assessors should state for how long the data will be stored. Research ethics codes and guidelines specify minimum durations, as do some publications. These may be of the order of 5 years, but typically 7–10 years for health-related data, and often there is no stated maximum. Thus, provided data are stored securely and can be maintained far longer, something that may be useful if longitudinal comparisons are sought in the future.

This information would normally be in the form of written participant information that is given to them, using language that can be clearly understood and without confusing technical and/or scientific jargon. It should also be in a language that they understand, so translated copies may be required in some circumstances. Without this information, participants cannot provide 'informed consent'. The provision of consent would normally be in writing using an approved 'Participant Information and Consent Form' (PICF), which would include statements saying that the participant understands what the testing entails, any risks, what will happen to the data and that they've had the opportunity to have any questions or concerns addressed. The PIS and ICF would normally be signed by the participant, assessor and witness. In some cases, there may be a clause that states that if the results indicate a health concern for the participant, test results may be forwarded to a relevant health/medical practitioner or a medical referral will be made; however, this must be clearly stated to participants and agreed by all, at the outset.

It should be noted that if the participant is a child, consent would be provided by their parent or guardian but that this should then be affirmed by the child giving their 'assent' to their participation.

Confidentiality, privacy, security, data access and usage of data

Data would typically be on secure institution/organisation property in locked cabinets in the case of hard copies and/or secure password-protected computers or servers. Increasingly data are stored on cloud-based servers, which also must follow good security practice in password protection and encryption (where possible). In research contexts, data may be collected and stored using coded identifiers, for which only the assessors are able to match the codes to individuals, as this adds further privacy and confidentiality. With research studies, data normally remain confidential, with any identifying data excluded from publications. However, in some cases this may be difficult, if, for example, the research involves elite sports people, such as Olympic medallists, where the population of individuals is so small that it enables accurate deductions about the identity of participants simply from the nature of the research. In such cases, this would need to be made clear to the participants within their PIS and ICF.

In sports physiological testing or clinical health exercise testing, data should be made available to the participant, coach or other relevant staff, health or medical practitioner, and the participant would need to agree to this in the PIS and ICF. In a sporting context, this may cause some concern for the participant if they perceived that their data may be used in the context of 'team selection' or other means of discrimination. This needs to be clearly established with all concerned, and the assessor must comply with the signed agreements. So, for example, if a coach or selection manager asked for the data at a later date but the participant had not agreed to their having access to the data, then the assessor is not permitted to give it to other persons. Hence clarity on such matters needs to be established in writing prior to any physiological testing activity, and participants may have this access to data included in their contracts.

In some circumstances, photographic images may be taken to illustrate the physiological testing procedures. If this is part of the procedure, the participant must be made aware of what images will be taken and what they would be used for and agree to this. Furthermore, if any images are to be used in subsequent publications, specific permission must be attained from the participant, and this may or may not involve de-identifying those in the images, for example, using pixilation of the face or obscuring the face with a 'black box'. Most institutions will have specific forms that address the publication of images, and these would need to be signed by the participant in addition to the standard PICF or equivalent 'non-research' form.

It should be stated that acquired data can only be used for the purposes that the participant has agreed to within the PIS and ICF. If the assessors perceive that they may wish to use the data for secondary purposes at a later date, such as writing a research paper on previously collected fitness or health data, this must have been specified and stated in the PIS and ICF and the participant knowingly agreed to this possibility.

In some clinical areas, particularly in rare diseases, new models of consent have been developed to enable the collation of data where individual data are scarce. While this wider sharing of data would seem to compromise some aspects of privacy, modified consent clauses have been developed and researched with participants understanding the need for large-scale data sharing and expect their data to be distributed and reused but require, nonetheless, that they be informed of such activities to maintain a level of protection and control. However, despite this wider sharing, the underlying principle must be the possible benefit for participants and others like them and must surpass the potential consequences for their privacy (Nghuyen et al., 2019).

Withdrawal of participant and their data

Within a research ethics submission, there would normally be a clause stating that participants are free to withdraw from the study at any stage without it affecting their relationship with the assessors or their organisation. If the participant has already completed the physiological assessments, a further clause may say that they can withdraw their data, provided it is identifiable as their data, prior to it being included in any data analyses or publication, again, without this affecting their relationship with the assessors or their institution. This option should be clearly stated on the PIS and ICF that they sign, along with whom they should contact in these circumstances.

Monitoring and reporting of activities: annual reports, adverse events and complaints

Ethics committees require regular, typically annual, reporting of the research projects for which they have given ethics approval. This regular monitoring provides those responsible with information on how an approved research project

is progressing, and eventually a final report would be required that outlines the outcomes of research undertaken and, where applicable, intended publications. In sports testing or health/clinical testing, there will be similar requirements for regular reporting, and these will be audited at intervals.

In addition to this, even with the best planned physiological testing procedures, there remains a risk, and this should be included in the PIS and ICF so that the participant is aware of the risk before agreeing to participate. As part of the establishment of the physiological testing activity, there must be a clear procedure for reporting adverse events. This may be both internal and external in the case of clinical trials. Where the physiological testing is for sport science support or health/medical assessments, there must be a clear procedure for reporting these events promptly – this means immediate reporting, rather than waiting to include the information in an annual report. When reported, such occurrences will be investigated by the relevant authorities, and the activity may be suspended during the investigation. The findings of the investigation will then determine whether the physiological testing may be resumed or terminated.

Clear procedures must also exist to deal with formal complaints. In the case of research, there will be an established committee, often composed of experts from an institution's research ethics and research governance bodies. The risk of complaints is minimised if the assessors adhere to stated and approved procedures. Complaints often stem from ambiguities, which an assessor can avoid if participants receive comprehensive and clear information within the PIS and signed ICF. Other complaints may relate to the nature of recruitment strategies used where, for example, an assessor has randomly displayed unapproved recruitment posters and signs in public areas. Similar organisations and procedures for dealing with complaints must be established within organisations that undertake sports-, health- and medical-related exercise testing.

Other considerations

If the participants are members of particular cultural groups or vulnerable populations, the assessors will need to consider the implications and undertake recruitment, attainment of consent and testing in a way that complies with the expectations of the ethical collection of data with these participants. For example, where children and minors under the age of 18 years are concerned, both participant informed consent and parent/guardian assent must be obtained. Within the UK, it is obligatory for assessors working with minors to have undergone, and be able to present evidence of, a formal, context-specific and up-to-date disclosure and barring service check (see: https://dbscheckonline.org.uk/).

Assessors should not seek ethics approval retrospectively. Situations whereby research may be undertaken on existing data sets are a specific scenario, with specific issues that are considered by the research ethics committee, including whether the participants had agreed to their data being used for research or teaching purposes when they were collected.

An assessor cannot recruit participants and collect research until an ethics committee has granted approval; this has to fall within the approval period. If the assessors wish to continue collecting data beyond this point, an assessor must request an extension to ethics approval.

Policies and regulations

American College of Sports Medicine Pre-Participation Screening. www.acsm.org/docs/default-source/default-document-library/read-research/acsm-risk-stratification-chart.pdf?sfvrsn=7b8b1dcd_6

Australian Code for the Responsible Conduct of Research. (2018). *National Health and Medical Research Council, Australian Research Council and Universities Australia*. Commonwealth of Australia, Canberra. www.nhmrc.gov.au/about-us/publications/australian-code-responsible-conduct-research-2018

British Association of Sport and Exercise Sciences (BASES) Code of Conduct. www.bases.org.uk/imgs/bases_code_of_conduct872.pdf

Exercise and Sport Science Australia. *Adult Pre-Exercise Screening System (APSS)*. www.essa.org.au/Public/ABOUT_ESSA/Adult_Pre-Screening_Tool.aspx?WebsiteKey=b4460de9-2eb5-46f1-aeaa-3795ae70c687

National Health Service. *Health Research Authority*. www.hra.nhs.uk/about-us/committees-and-services/res-and-recs/research-ethics-service/

Nghuyen, M. T., et al. (2019). Model consent clauses for rare disease research. *BMC Medical Ethics*, 20(1), 55.

NHS Health Research Authority. www.hra.nhs.uk/

NHS Research Ethics Service. www.hra.nhs.uk/about-us/committees-and-services/res-and-recs/

UK Government, General Data Protection Regulations. www.gov.uk/government/publications/guide-to-the-general-data-protection-regulation

UK Research and Innovation. www.ukri.org/about-us/policies-and-standards/research-integrity/

1.3 Health and safety in duty of care

Evaluating and stratifying risk

S. Andy Sparks, Kelly Marrin, and Craig A. Bridge

The processes involved in data collection and participant, patient or client assessment in exercise physiology present unique challenges for researchers, clinicians and practitioners – collectively referred to as assessors from this point onwards. The need to collect data in diverse environments that are often less controlled than a traditional laboratory setting but relevant to the assessment and/or research question can further complicate matters. During any physiological testing, an assessor has a duty of care to the individual(s) under his or her supervision. In this context, duty of care represents a formalisation of the social responsibilities that individuals, laboratories and organisations have to research participants, patients or clients in their care. It requires assessors to adhere to standards of reasonable care whilst supervising or conducting any laboratory or field-based procedure that may foreseeably cause harm. Consequently, a key priority is the duty of care for the participant or patient, along with the health and safety of the individuals involved in the data collection itself. Therefore, in order to act reasonably and foresee the possible causes of harm, assessors need to formally identify hazards or risks and implement risk mitigation strategies before any data collection procedures take place. This chapter is intended to provide clear guidelines and suggestions for the processes of hazard identification, risk assessment and mitigation. Assessors and organisations responsible for the physiological assessment of human participants should consider the contents and associated recommendations within this chapter.

Professional obligations

Safe practices and procedures should underpin all laboratory and field-based activities for several vital reasons. Firstly, many assessors will be working either for an organisation, fan employer or as self-employed individuals; in these contexts, assessors and places of work must adhere to the requirements set out in the Health and Safety at Work Act (1974). This outlines the legal requirement for safe practices and environments, along with the paramount importance of client welfare. These principles form the foundation of the BASES Code of Conduct; this framework insists that members use the utmost integrity and concern for their participants, patients or clients and act without jeopardising any individual's safety. Under appropriate assessor supervision, the BASES Code of Conduct ensures that undue risk is

DOI: 10.4324/9781003045281-5

avoided (BASES, 2017) – these issues are also covered in some detail in the chapter relating to ethics. It is essential that all aspects of data collection and client sport and exercise science support are assessed for appropriateness and safety before anyone is exposed to unnecessary harm. It is also imperative that there is an appropriate procedure to gain a client's informed consent and that data management occurs in accordance with relevant data protection legislation. Furthermore, the practitioner must recognise their limitations in terms of qualifications, experience, expertise and competence and operate safely within these limits. The following sections detail the chronological order in which processes should occur to ensure assessors meet these key considerations.

Hazard identification

The first key step in duty-of-care-based risk mitigation is the identification of hazards. This should focus not only on research participants or client(s) but also on individuals working with these individuals or, indeed, in isolation. This is especially relevant where anyone may be exposed to potential risks as part of normal working activities and should be addressed within an organisation's lone working policy. In this context, a hazard represents anything that has the potential to harm the health and safety of any person involved in the process of assessing a client or participant, preparing and/or using equipment or anyone in proximity to the testing area. Such hazards can typically be categorised into five types (Table 1.3.1). Unless and until an assessor identifies potential hazards, the rest of

Table 1.3.1 Classification and explanation of hazard types relevant to physiological testing

Hazard Type	*Explanation/Example*
Physical	This is the most common hazard and may include trips, slips, falls, noise or extremes of ambient temperature and changes in physiological state in response to exertion.
Ergonomic/ mechanical	These factors might result in damage to the musculoskeletal system or skin. Such hazards are common with the use of ergometry or sports equipment, but may also be caused by manual handing or repetitive movements.
Chemical	These hazards include exposure to hazardous substances, most likely in wet laboratories or when using cleaning products for hygiene. They may also include the ingestion of substances/ supplements used in nutrition-based experimental trials.
Biological	These hazards are common where there is either close contact between individuals or the exposure to human biological samples such as blood, urine or saliva.
Psychological	This form of hazard is possible where either severe exercise is needed, participants are exposed to mental fatigue or during exposure to confined spaces, such as during some forms of body composition assessment. Risks may also be present where potentially sensitive information is collected (body composition, nutritional analysis, assessments of disordered eating, fitness assessments).

the risk management process cannot begin. Hazards should also be recorded and reviewed at least annually following an accident or 'near miss', if something in the environment has changed or if modifications occur to a standard operating procedure.

Risk assessment

The assessment of risk is the key component of health and safety practice and management. It is about taking reasonable and logical steps to prevent ill health (HSE, 2012). Furthermore, there is also a legal requirement that all activities are risk assessed and documented in order to ensure what is reasonably practicable has been done to mitigate risks (Health and Safety at Work Act, 1974). This essentially means that there needs to be a balance of the level of risk with the cost, time and practicality of the measures needed to control the risk (HSE, 2016); there is no expectation for an assessor to anticipate unforeseeable risks, nor where mitigation measures are grossly disproportionate to the level of risk (HSE, 2014).

Five steps to risk assessment (HSE, 2014)

1 Identify potential hazards:

- List the activity in steps, and consider the equipment or materials within the specific environment it is to be used in.
- List the hazards for each of the steps and/or pieces of equipment.

2 Identify who might be harmed and how:

- This is likely to be those in immediate contact or presence of the procedure or equipment, but not always.
- Think carefully about the five types of hazards. This is particularly important for those exposed to potentially harmful substances that are chemical, nutritional or biological in nature.
- Where exposure is to biological hazards, such as viruses and microorganisms, careful consideration regarding the method of transmission is vital and may require specialised considerations (Tipton et al., 2020). Consultation of the Health and Safety Executive's resources on blood-borne viruses (HSE, 2001), prevention of infection in laboratories (HSE, 2010) and control of substances hazardous to health (COSHH) (HSE, 2012) are recommended.

3 Evaluate the risks – consider the existing controls and assess the extent of the risks which remain:

- List the existing risk controls.
- Use the example (or similar) risk matrix (Table 1.3.2) to calculate the level of risk (the product of the outcome impact and its probability) and then again to calculate the risk with the controls in place.
- List the residual hazards.

- List the additional risk controls required to reduce the residual risk.
- Evaluation should also be done in conjunction with evidence from the literature. This is particularly important for scenarios that involve the ingestion of a substance because safe consumption thresholds may be subject to change with emerging evidence.

4 Record the findings of the assessment – including the controls necessary and any further action needed to reduce risk sufficiently:

- Use a standardised proforma for the recording of this process. These are often stipulated by institutions or can be adapted from the HSE (2014) examples.
- Document that those affected have been consulted.
- Participant pre-exercise screening is a good example of a risk evaluation process that enables assessment and mitigation of potential risks specific to populations – Warburton et al. (2011) provide a comprehensive set of recommendations for this.

5 Review, revise and modify the assessment – this is especially important if the nature of the procedures or equipment changes or if developments suggest existing risk assessment may no longer be valid.

Ensure a risk assessment has a suitable title, details the name of the person completing it and is dated. Further, the person with overall responsibility, for example, the laboratory manager or head of department, should review all risk assessments and counter-sign them.

Key resources for risk assessment

How to control risks (HSE, 2016).
A brief guide to COSHH (HSE, 2012).
Examples of risk assessment documents (HSE, 2014).

Other key considerations

Hygiene

One underpinning risk mitigation strategy that is essential to exercise physiology is to ensure measures are in place to optimise hygiene via effective handwashing and/or use of alcohol gel, cleaning surfaces regularly, sterilising equipment, using disposable equipment where appropriate and performing after-use decontamination (Tipton et al., 2020).

Incidents and accidents

Appropriate provision for first aid equipment and a suitably qualified first aid–trained individual are minimum requirements. Given the nature of much of the

work in sport and exercise physiology, it may also be a reasonable expectation that there is access to an automated external defibrillator (AED). A full assessment of the first aid needs of specific locations and procedures should be part of a risk assessment. Any event or 'near miss' should be formally documented under the regulations of the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR: www.hse.gov.uk/riddor), and the current risk assessments should then be reviewed to ensure they are effective.

Emergency procedures

In data collection or client support situations, which may be in a field or laboratory setting, an assessor should consider what to do in an emergency and create a clear emergency plan. The plan should consider what to do in the case of an emergency; how to communicate with others, including the emergency services; and how to evacuate, for example. A more detailed list of such considerations is available in the Health and Safety Toolbox (HSE, 2016).

Table 1.3.2 Example risk quantification guidance assessment tool based on the probability and severity of the outcome impact.* Cells denote likely risk with example interpretations in parentheses.

Outcome Impact						
	Severe	Medium (Moderate)	Medium (Moderate)	High (Substantial)	Extreme (Intolerable)	Extreme (Intolerable)
	Major	Low (Acceptable)	Medium (Moderate)	Medium (Substantial)	High (Substantial)	Extreme (Intolerable)
	Moderate	Low (Acceptable)	Low (Acceptable)	Medium (Moderate)	Medium (Substantial)	High (Substantial)
	Minor	Low (Trivial)	Low (Acceptable)	Low (Acceptable)	Medium (Moderate)	Medium (Moderate)
	Minimal	Low (Trivial)	Low (Trivial)	Low (Acceptable)	Low (Moderate)	Low (Moderate)
		Rare	Unlikely	Possible	Likely	Probable
				Probability		

Risk Rating	*Risk Interpretation*
Trivial	No action required.
Acceptable	No preventative action, but consider cost-effective measures. Continued monitoring required.
Moderate	Implement measures to reduce risk. The speed of implementation should be proportional to the number of people exposed.
Substantial	Do not commence procedures until extent of risk is reduced. If this outcome occurs during a review of existing processes, seek to mitigate risk as soon as possible.
Intolerable	The level of risk must be reduced before work can either start or progress. If this is not possible, procedures are prohibited.

*One should use a risk classification matrix as a guide and interpret outcomes with caution. Use of such a matrix should only form part of the risk assessment process (Peace, 2017).