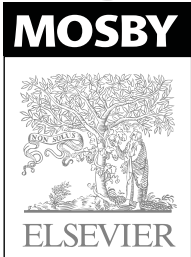




evolveresources
learning system

ESSA's Student Manual for Health, Exercise and Sport Assessment

Jeff Coombes • Tina Skinner



ESSA:
EXERCISE & SPORTS SCIENCE AUSTRALIA

ESSA's Student Manual for Health, Exercise & Sport Assessment

Sample proofs @ Elsevier Australia

ESSA DISCLAIMER

This textbook covers some elements included in the Exercise & Sports Science Australia (ESSA) Exercise Science accreditation framework. For accreditation purposes, universities are required to evaluate their own program and the content of this text to ensure full coverage of the ESSA Exercise Science elements, and to satisfy the curriculum requirements outlined in the National University Course Accreditation Program (NUCAP). ESSA and its officers have not received any financial benefits from the naming of products and the naming of products does not mean ESSA endorses the products.

Sample proofs @ Elsevier Australia

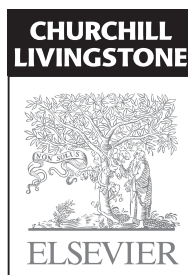
ESSA's Student Manual for Health, Exercise & Sport Assessment

Jeff Coombes BEd (Hons), BAppSc, MEd, PhD, AEP

Professor of Exercise Science, School of Human Movement Studies
The University of Queensland, Brisbane, QLD, Australia

Tina Skinner BAppSc (HMS — ExSci) (Hons), GCHigherEd, PhD, AEP

Lecturer in Clinical Exercise Physiology, School of Human Movement Studies
The University of Queensland, Brisbane, QLD, Australia



Sydney Edinburgh London New York Philadelphia St Louis Toronto



Mosby
is an imprint of Elsevier

Elsevier Australia. ACN 001 002 357
(a division of Reed International Books Australia Pty Ltd)
Tower 1, 475 Victoria Avenue, Chatswood, NSW 2067

© 2014 Elsevier Australia.

This publication is copyright. Except as expressly provided in the Copyright Act 1968 and the Copyright Amendment (Digital Agenda) Act 2000, no part of this publication may be reproduced, stored in any retrieval system or transmitted by any means (including electronic, mechanical, microcopying, photocopying, recording or otherwise) without prior written permission from the publisher.

Every attempt has been made to trace and acknowledge copyright, but in some cases this may not have been possible. The publisher apologises for any accidental infringement and would welcome any information to redress the situation.

This publication has been carefully reviewed and checked to ensure that the content is as accurate and current as possible at time of publication. We would recommend, however, that the reader verify any procedures, treatments, drug dosages or legal content described in this book. Neither the author, the contributors, nor the publisher assume any liability for injury and/or damage to persons or property arising from any error in or omission from this publication.

National Library of Australia Cataloguing-in-Publication Data

National Library of Australia Cataloguing-in-Publication entry

Author:	Coombes, Jeff, author.
Title:	ESSA's student manual for health, exercise & sport assessment / Jeff Coombes ; Tina Skinner.
ISBN:	9780729541428 (paperback)
Notes:	Includes index.
Subjects:	Physical fitness—Measurement. Physical fitness—Evaluation. Exercise—Physiological aspects—Measurement. Sports—Physiological aspects—Measurement.
Other Authors/Contributors:	Skinner, Tina, author.
Dewey Number:	612.044

Publisher: Melinda McEvoy
Developmental editors: Martina Vascotto
Project managers: Natalie Hamad and Anitha Rajarathnam
Photography by Porfyri Photography
Edited by Forsyth Publishing Services
Proofread by Fiona Van Dam
Cover and internal design by Stan Lamond
Index by Robert Swanson
Typeset by Toppan Best-set Premedia Limited

Foreword

Exercise Science in Australia is a rapidly growing qualification. An exercise science qualification provides the graduate with the knowledge and skills to apply the science of exercise for health, fitness and sports performance.

The assessment of health, fitness and sports performance is an important aspect of exercise and sports science and should be one of the most important skills a graduate from an exercise science program has developed. Assessments not only help to develop an appropriate, individualised program, they also provide an imperative function of screening and risk stratification for heart disease, other chronic diseases and injuries.

This text is a unique book in the Australian setting, providing the theoretical understanding and procedures to allow Australian and New Zealand exercise science graduates to work competently within the health, exercise and sports industries. It is also the first text available in Australia that has considered Exercise & Sports Science Australia's (ESSA's) exercise science accreditation framework.

The *ESSA Student Manual for Health, Exercise and Sport Assessment* is a beneficial text for any student or graduate of an exercise and sports science degree, providing content related to the knowledge and skills required to undertake an assessment, no matter the setting.

The editors of this text are expert educators and researchers who have structured this text based on years of experience teaching the content to cover commonly performed health, exercise and sports assessments.

ESSA is the peak organisation in Australia representing and advocating for university trained exercise and sports science professionals, including the allied health profession of exercise physiology. As the peak professional body representing exercise and sports science in Australia, ESSA provides national and international leadership and advocacy on key issues and supports its members and the community by fostering excellence in professional practice, education and training, and research.

One of the association's key roles is to promote professional standards by providing high quality education, accreditation and management of standards. For this reason, ESSA is pleased to support this text as one way we look to ensure consistent and high standards within our professions.

In my opinion, the most important element of this textbook is the easy to read style and strong use of imagery, which will help readers understand and perform valid and reliable assessments of health, exercise and sports.

Anita Hobson-Powell
Executive Officer
Exercise & Sports Science Australia

Contents

Preface	ix
Contributors	x
Exercise science nomenclature	xii
Laboratory safety, cleaning and disinfecting	xiii
Interpretation, feedback and discussion	xx
1 Equipment calibration and verification	1
<i>Tina Skinner and Corinne Caillaud</i>	
2 Blood analysis	12
<i>Jeff Coombes and Cecilia Shing</i>	
3 Cardiovascular health	29
<i>Jeff Coombes and Andrew Williams</i>	
4 Anthropometry	59
<i>Tina Skinner, Gary Slater and Kellie Pritchard-Peschek</i>	
5 Physical activity	92
<i>Jeff Coombes and Stewart Trost</i>	
6 Pre-exercise health screening	115
<i>Jeff Coombes and Kevin Norton</i>	
7 Neuromuscular strength, power and strength endurance	133
<i>Tina Skinner, Robert U. Newton and Gregory Haff</i>	
8 Flexibility	174
<i>Sally Lark, Tania Brancato and Tina Skinner</i>	
9 $\dot{V}O_2\text{max}$	200
<i>Jeff Coombes and Chris Gore</i>	
10 Submaximal tests for cardiorespiratory fitness	219
<i>Jeff Coombes and Chris Askew</i>	

Contents *continued*

11	Lactate threshold	236
	<i>David Bishop and Tina Skinner</i>	
12	High intensity exercise	258
	<i>Tina Skinner, Adrian Gray and David Jenkins</i>	
13	Nutrition	295
	<i>Jeff Coombes and Cameron McDonald</i>	
14	Functional measure for older adults	319
	<i>Tina Skinner and Kate Bolam</i>	
15	Exercise capacity	351
	<i>Jeff Coombes and Mia Schaumberg</i>	
16	Pulmonary function	368
	<i>Norm Morris, Troy Cross, Surendran Sabapathy, Simon van Rosendal and Tina Skinner</i>	
17	Resting and exercise electrocardiography (ECG)	386
	<i>Jeff Coombes, Steve Selig and Julian Sacre</i>	
18	Data analysis	407
	<i>Jeff Coombes and Dennis Taaffe</i>	
	Appendix A — Pre-exercise test procedures	425
	Appendix B — Contraindications to exercise testing	428
	Appendix C — Borg's Rating of Perceived Exertion (RPE) Scale	430
	Appendix D — Indications for stopping an exercise test	431
	Index	433

Preface

Students graduating from an Exercise Science program should be able to competently conduct a health and fitness evaluation and perform common health, exercise and sport-related assessments. This manual contains the basic theory and detailed step-by-step protocols to enable students to develop these competencies.

Specifically, this manual identifies and explains the common processes and equipment required to conduct assessments in various aspects of health, exercise and sport. Emphasis is also placed on the need for accurate measuring devices with a separate practical covering the rationale and fundamentals of calibration and verification. The scientific rationale, purpose, assumptions and validity of procedures are described, along with the limitations, contraindications and additional considerations where appropriate. The manual focuses on the analysis, interpretation and communication (e.g. feedback and discussion) of test results to the participant. Practicals contain worked examples that show how these important steps can be conducted and provide advice for common scenarios. Safety for the tester and the participant is addressed throughout the manual with a separate section describing cleaning and disinfection from a contemporary occupational health and safety perspective.

The content of this manual has been developed by the authors over many years of teaching this material. It is our observation, while teaching these skills, that a course/subject/unit containing this content is one of the most challenging, enjoyable and rewarding that a student will complete during their degree. An important reason for this, we believe, is because it requires and allows students to develop individual skill competency. We have witnessed that the successful completion of a course/subject/unit that teaches and assesses technical skill competency gives students more confidence during their practicum placements and within the industry. It may also lead students to seek placements and work in areas of exercise and sports science that they may not have previously considered (e.g. as a cardiac technician or sport scientist).

The manual is a general academic instructional guide of common skills in exercise and sports science and is not intended to directly align with university course/subject/unit or individual accreditation requirements of any professional organisations.

Jeff Coombes and Tina Skinner

Contributors

Chris Askew BAppSc (HMS) (Hons), PhD

Senior Research Fellow
University of the Sunshine Coast
Maroochydore, Qld, Australia

David Bishop BHMS Ed (Hons), PhD

Research Leader (Sport) Institute of Sport
Exercise and Active Living
Victoria University
Melbourne, Vic, Australia

Kate Bolam BAppSc (HMS—ExSci) (Hons), AEP

School of Human Movement Studies
The University of Queensland
Brisbane, Qld, Australia

Tania Brancato BScAppHMS (ExSci) (Hons), GD (Ex Rehab), GCHigher Ed, AEP

School of Human Movement Studies
The University of Queensland
Brisbane, Qld, Australia

Corinne Caillaud BSc, MPhil, PhD

Associate Professor
Faculty of Health Sciences
The University of Sydney
Sydney, NSW, Australia

Jeff Coombes BEd (Hons), BAppSc, MEd, PhD, AEP

Professor of Exercise Science
School of Human Movement Studies
The University of Queensland
Brisbane, Qld, Australia

Troy Cross BExSc (Hons), PhD

Research Fellow
School of Allied Health Sciences
Griffith Health Institute and Heart Foundation
Research Centre
Griffith University
Southport, Qld, Australia

Christopher J Gore DipT, BEd (Hons), PhD

Head of Physiology
Australian Institute of Sport
Canberra, ACT, Australia

Adrian Gray BAppSc (HMS — ExSci) (Hons), GCHigherEd, PhD

Lecturer and Clinical Placement Educator
School of Science and Technology
University of New England
Armidale, NSW, Australia

Gregory Haff BS, MS, PhD

Senior Lecturer of Exercise and Sports Science
School of Exercise and Health Sciences
Edith Cowan University
Joondalup, WA, Australia

David Jenkins PGCE, BA(Hons), MSc, PhD, PGDip Hum Nutr

Associate Professor of Exercise Science
School of Human Movement Studies
The University of Queensland
Brisbane, Qld, Australia

Sally Lark BSc, BSc (Hons), M.Med.Sc, PhD

Senior Lecturer
School of Sport & Exercise, College of Health
Massey University, Wellington, New Zealand

Cameron McDonald APD, AN, AEP

School of Human Movement Studies
The University of Queensland
Brisbane, Qld, Australia

Norm Morris BSc, BAppSc (Physiotherapy), PhD, DipEd

Professor and Deputy Head (Research)
School of Allied Health Sciences
Griffith Health Institute and Heart Foundation
Research Centre
Griffith University
Southport, Qld, Australia

Contributors *continued*

Robert Newton HMS (Hons), MHMS, PhD, AEP

Professor of Exercise and Sports Science
Edith Cowan University
Health and Wellness Institute
Joondalup, WA, Australia

Kevin Norton BEd(PE) (Hons), MA, PhD, FACSM

Professor of Exercise Science
School of Health Sciences
University of South Australia
Adelaide, SA, Australia

Kellie Pritchard-Peschek BAppSc (HMS — ExSci) (Hons), PhD

Sport Scientist (Swimming)
Swiss Federal Institute of Sport
Magglingen SFISM, Switzerland

Surendran Sabapathy BExSc (Hons), PhD, AEP

Senior Lecturer, School of Allied Health Sciences
Griffith Health Institute and Heart Foundation Research Centre
Griffith University
Southport, Qld, Australia

Julian Sacre BAppSc (HMS — ExSci) (Hons), PhD

Research Fellow
Baker IDI, Heart and Diabetes Institute
Melbourne, Vic, Australia

Mia Schaumberg BExSS (Hons)

Associate Lecturer
School of Human Movement Studies
The University of Queensland
Brisbane, Qld, Australia

Steve Selig BSc PhD, AEP

School of Exercise and Nutrition Sciences
Deakin University
Burwood, Vic, Australia

Cecilia Shing BAppSc, BSc(Hons), PhD, AEP

Senior Lecturer
School of Health Sciences
The University of Tasmania
Launceston, Tas, Australia

Tina Skinner BAppSc (HMS — ExSci) (Hons), GCHigherEd, PhD, AEP

Lecturer in Clinical Exercise Physiology
School of Human Movement Studies
The University of Queensland
Brisbane, Qld, Australia

Gary Slater BSc, GDNutDiet, MSc, PhD

Senior Lecturer
School of Health and Sport Sciences
University of the Sunshine Coast
Maroochydore, Qld, Australia

Dennis Taaffe DipTeach, BSc, MSc, PhD, DSc, MPH, FACSM, AEP

Professor of Exercise Physiology
School of Environmental and Life Sciences
The University of Newcastle
Ourimbah, NSW, Australia

Stewart Trost BSc, MSc, PhD

Professor of Physical Activity and Health
School of Human Movement Studies
The University of Queensland
Brisbane, Qld, Australia

Simon van Rosendal BAppSc (HMS — ExSci) (Hons), PhD, MBBS

School of Human Movement Studies
The University of Queensland
Brisbane, Qld, Australia

Andrew Williams BAppSc(Ex & Sport), BSc(Hons), PhD, GCULT, AEP

Senior Lecturer
School of Human Life Sciences
The University of Tasmania
Launceston, Tas, Australia

Exercise science nomenclature

The following terms are used throughout the manual to refer to qualifications, accreditations and professions associated with applying the science of exercise for health, fitness and sports performance. Although from the Australian context, defining these terms will assist with the use of the manual in broader contexts.

Accredited Exercise Physiologist (AEP): a university qualified individual who has been accredited by Exercise & Sports Science Australia (ESSA) to provide exercise prescription, programming and delivery services for people with chronic disease and/or complex medical conditions. The person is recognised as an allied health professional.

Exercise Science: a university qualification that provides the graduate with the knowledge and skills to apply the science of exercise for health, fitness and sports performance.

Exercise scientist: an individual with a university Exercise Science qualification.

Exercise & Sports Science Australia (ESSA): the peak professional organisation committed to establishing, promoting and defending the career paths of university qualified exercise scientists, sport scientists and accredited exercise physiologists.

Accredited sport scientist: a university qualified individual who has been accredited by ESSA to work as a scientist in or around high performance sport.

Laboratory safety, cleaning and disinfecting

Tina Skinner and Simon van Rosendal

Learning objectives

- Demonstrate an understanding of the theoretical basis, terminology, application, limitations and protocol considerations of laboratory safety, cleaning and disinfecting procedures
- Recognise and apply additional safety procedures as required for specific exercise science technical skills
- Perform appropriate cleaning and disinfecting procedures

Equipment and other requirements

- Non-latex gloves of appropriate size (S, M, L)
- Paper towel
- Antimicrobial soap or alcohol based/antiseptic rubs
- Cleaning solution (e.g. Sonidet)
- Disinfecting solution (e.g. Viraclean)
- Alcohol wipes
- Cleaning solution container/s
- Breathing tube solution container/s
- Spray bottle
- Sink
- Drying cabinet
- Biohazardous waste containers
- Hanging rack
- Sharps container
- Lab coat
- Safety glasses
- First aid kit

OCCUPATIONAL HEALTH AND SAFETY

All Australian universities and healthcare centres (such as hospitals) have strict occupational health and safety guidelines. The institution-specific guidelines should be read before participating in practical sessions. In addition, your institution may have an associated safety declaration form that will need to be completed before being permitted to participate. A risk assessment should be conducted by the instructor for all chemicals or biological material that are to be used during practical classes.

EMERGENCIES

It is important to become familiar with the emergency/evacuation procedures for your workplace. This includes the location of:

- emergency exits
- meeting points
- fire fighting hoses and extinguishers
- defibrillators
- safety showers
- eyewash stations
- telephones and procedures for calling for help if required.

PERSONAL PROTECTIVE EQUIPMENT

You should arrive 'ready to exercise' for all practical sessions detailed within the practicals. From a safety perspective, this requires wearing appropriate exercise clothing and covered footwear (exercise shoes) during practical classes. Thongs, open weave shoes, sandals and so forth are not appropriate footwear. Long hair should be tied back to avoid injury.

In addition to these standard safety precautions, there are additional precautions that must be adhered to when completing specific technical skills. These will be detailed at the start of the appropriate practicals. For example, the blood analysis practical requires wearing the following personal protective equipment (PPE):

- lab coat
- approved safety glasses
- gloves.

Safety glasses should remain on the face throughout the practical, not lifted and rested on top of the head.

PREPARATION FOR CLASS

It is recommended that you prepare for class by arriving well hydrated and having consumed adequate food 2–4 hours prior to the start of class, unless you are specifically instructed not to do so (e.g. prior to the blood analysis practical). Food and drink (including drinking from water bottles) must not be consumed in laboratories.

You should also inform your instructor if you have any existing medical conditions or injuries that may limit your ability to exercise safely. Similarly, if you know that you will have difficulties with a specific skill or session (e.g. if you have an aversion to needles or feel faint when having blood taken), then you should discuss this with the demonstrator before the session.

FIRST AID

The likelihood of a participant experiencing an adverse event while exercising (e.g. chest pain, dyspnoea [shortness of breath] or dizziness) is quite low. Although extremely rare, serious complications such as myocardial infarction are also possible during some of the more demanding exercise protocols. Should complications arise, an individual with first aid training, including cardiopulmonary resuscitation (CPR), should be on hand. It is recommended that you complete courses in administering first aid and CPR before taking part in the practicals. At a minimum, the instructor should have completed first aid and CPR courses to enable them to deal with an untoward event occurring within the teaching laboratory.

PROCEDURE FOR FIRST AID IN CASE OF INJURY, ILLNESS OR CHEMICAL/BIOLOGICAL SPILL

- At the start of the first session, familiarise yourself with the safety facilities of the teaching laboratory, including the location of emergency equipment, first aid kits and ice packs.
- First aid should be administered by a person who has completed first aid training.
- Immediately report all exposure to chemicals, injuries and illnesses, no matter how small, to the instructor.
- Non-injury causing incidents, such as spills, electrical faults or damage to equipment, must also be reported to the instructor.

Eye injuries

- Eye injuries are always serious, whether caused by chemical or mechanical injury, or splash by biological material.
- Treatment requires immediate and prolonged flushing with water (20 minutes minimum) at the eyewash station (preferable) or under a tap.
- Eyelids should be held open during flushing.
- Medical advice should be obtained for an eye injury.
- The Material Safety Data Sheet (MSDS) for the chemical involved should accompany the student if it is necessary to seek medical treatment.

Chemical or biological spills on skin

- Thoroughly wash the affected area with copious quantities of water.
- Remove contaminated clothes.
- Consult a MSDS to determine appropriate first aid. The MSDS for the chemical involved should accompany the student if it is necessary to seek medical treatment.

Ingestion (swallowing)

- Do NOT induce vomiting.
- Seek medical advice or contact a poisons information centre.

Sharps injuries

- Wash the wound and encourage bleeding.
- Seek medical advice.

Unwell or dizzy

- If a student is feeling unwell or dizzy when participating in an experiment, encourage them to stop immediately and sit or lie down.

Incident reporting

Should any injury, illness or incident occur during participation in the teaching laboratory, it is important to report it to the instructor immediately. Incidents that don't cause injury, such as spills, must also be reported to the supervisor. Please also ensure that any broken or faulty equipment is reported to the instructor so that it can be repaired to avoid any adverse events occurring during subsequent and/or inadvertent use.

It is likely that your institution will require documentation of all injuries, illnesses and incidents. It is recommended that these documents be completed as soon as possible to ensure accurate reporting.

HAND WASHING

Hand washing is a component of what is referred to as *standard precautions* in healthcare settings. These are infection control practices that all individuals involved in healthcare settings should use to reduce the risk of transmission of microorganisms, thereby protecting both the healthcare worker and the participants from contact with infective agents. Hand washing is used in conjunction with the appropriate use of protective gloves (for example, gloves should be used in addition to hand washing for points 2 and 3 below). The World Health Organization (WHO) has released the *5 Moments of Hand Hygiene* [1] which have been identified as the critical times when hand washing should occur.

- 1 Before touching a participant (e.g. shaking hands, clinical examination, measuring skinfolds).
- 2 Before doing a procedure (e.g. lancet of finger for blood collection).
- 3 After a procedure or body fluid exposure risk (e.g. after blood sample collection).
- 4 After touching a participant (e.g. shaking hands, clinical examination, measuring skinfolds).
- 5 After touching a participant's surroundings (e.g. when leaving after finishing a consult in which you have touched any object in the participant's surroundings even if the participant has not been touched).

It is good practice to start adhering to the *5 Moments Of Hand Hygiene* within the practical sessions so that the process becomes habit. Either antimicrobial soap (that is rinsed under running water) or alcohol based/antiseptic rubs (that do not need to be washed off) should be made available to you.

CLEANING, DISINFECTION AND STERILISATION

The practicals described within this textbook involve the use of multiple pieces of exercise equipment (e.g. bicycle ergometers) and associated items to assist with participant monitoring and data collection (e.g. heart rate monitors). These items will be shared between participants and thereby carry a risk of contamination that may be transferred between users. Therefore, all of the equipment that you use when testing must be adequately cleaned, disinfected or sterilised following use. Cleaning refers to the '*removal of all adherent visible soil from the surfaces, crevices, joints, and lumens of instruments, and is normally accomplished using water with detergents or enzymatic products*'. [2] Disinfecting is a more meticulous thermal or chemical process that removes or kills the majority of microorganisms (e.g. bacteria, fungi, viruses) with the exception of high numbers of bacterial spores. [2] Sterilisation is a more meticulous process again, involving the complete destruction of all forms of microorganism, including bacteria, viruses, fungi and spores. [2] To be effective, disinfection and sterilisation processes must be preceded by fastidious mechanical or manual cleaning to remove all foreign material. [2]

Most of the equipment described in the following practicals is classed as non-critical medical devices, which means it either does not come into direct contact with the participant or comes into contact with intact skin only. [2] Examples of such equipment include heart rate monitors and watches, stethoscopes and blood pressure cuffs. The cleaning and disinfecting of such devices is very important to prevent transfer of common microorganisms that can survive on these surfaces for long periods (e.g. methicillin-resistant *Staphylococcus aureus*, *Escherichia coli*).

Equipment that is categorised as semi-critical or critical medical devices has also been described in the following practicals. Semi-critical devices are those that come in contact with mucous membranes or non-intact skin but do not actually penetrate with normal use. These include the mouthpieces of breathing apparatus used for $\dot{V}O_{2\max}$ (contact mucous membranes) and blood analysers (contact non-intact skin). These items must be diligently disinfected after every use. Viruses such as Epstein-Barr virus (glandular fever) can be transmitted from the saliva of infected individuals if disinfecting is inadequate. Use of critical medical devices that penetrate the skin

(i.e. lancets for blood collection) is limited in the following practicals. The critical medical devices described will be single use only and must be discarded into a sharps container immediately after use. Although these are single use only, they directly penetrate skin and thus carry a greater risk of infection. It is therefore important to disinfect the skin with alcohol wipes and allow to dry before puncturing so that the risk of infection is reduced.

Detergents and disinfectant solutions

There are many different types of detergents and disinfectant solutions that are used across various institutions. The detergents and disinfectant solutions detailed below are commonly used within hospitals and universities around Australia. You should always wear gloves and safety glasses when handling these chemicals.

Sonidet

- Sonidet is a bacteriostatic (i.e. stops bacteria from reproducing) *detergent* intended for use in the cleaning of non-critical medical devices.[3]
- The solution is a *cleaner*, not a *disinfectant*,[3] and therefore a disinfectant (e.g. Viraclean) should be used in conjunction with Sonidet.
- When diluted correctly, Sonidet should be a clear odourless liquid detergent.[3] If the solution is still yellow after it has been diluted then too much Sonidet has been added.
- The correct dilution of Sonidet is 5 mL per 1 L of water.[3]
- It rinses freely off cleaned equipment so that no residue remains.[3]

Preparation

- 1 Put on a pair of gloves.
- 2 Using a measuring cup, measure 5 mL of Sonidet per 1 L of water into a container marked 'Sonidet'.
- 3 Dilute with the appropriate volume of cold tap water.
- 4 Sonidet solution should be changed when it becomes cloudy (indicates excessive fouling) or if it has been in use for ≥ 24 hours.[3]

Viraclean

- Viraclean is a hospital grade *disinfectant* that kills numerous common bacteria (i.e. is bactericidal) and viruses, and is intended for use in the disinfecting of non-critical and semi-critical medical devices.[4]
- Viraclean solution is not diluted when used so should maintain a pink colour.[4]
- The required exposure time is 10 minutes.[5]
- It rinses freely off disinfected equipment so that so that no residue remains.

Preparation

- 1 Put on a pair of gloves.
- 2 Pour enough 100% Viraclean into a container marked 'Viraclean' to ensure the items being disinfected are totally submerged.
- 3 Viraclean should be changed after every use.

Milton

- 1 Milton solution is another hospital grade *disinfectant* that kills numerous common bacteria (i.e. is bactericidal), viruses, fungi and spores. It can be used for the disinfection of non-critical and semi-critical medical devices, as well as various other equipment items.

- 2 The required exposure time is 30 minutes (however the solution remains sterile for 24 hours).[6]
- 3 The correct dilution of Milton solution is 6.25 mL in 1 L of water.[6]
- 4 It does not need to be rinsed off disinfected equipment before the equipment is used again.[7]
- 5 Milton solution is dilute (2%) sodium hypochlorite solution (bleach) and may damage or bleach clothes on contact.

Preparation

- 1 Put on a pair of gloves.
- 2 Use the small measuring cup provided to measure 6.25 mL of Milton solution per 1 L of water into the appropriate $\dot{V}O_2$ breathing tube disinfecting container.
- 3 Dilute with the appropriate volume of cold tap water.

Disinfection of general teaching laboratory equipment (e.g. treadmills, mats, bikes, heart rate watches, sphygmomanometers)

- 1 Put on a pair of gloves.
- 2 Use 100% undiluted Viraclean in a spray bottle.
- 3 Spray and wipe down with paper towel all surfaces that may have come in contact with bodily fluids e.g. secretions such as sweat and saliva.
- 4 Discard paper towel into a clinical waste bin.

Cleaning and disinfecting of stethoscope ear pieces, heart rate monitor straps and chest transmitters

- 1 Put on a pair of gloves.
- 2 Rinse excessive sweat off heart rate monitor strap under cold tap water.
- 3 Place the heart rate monitor strap and stethoscope ear-pieces in the prepared Sonidet solution.
- 4 Gently agitate the solution until the equipment is clean and then rinse under cold tap water.
- 5 Place the heart rate monitor strap, stethoscope ear-pieces as well as the heart rate transmitter into prepared Viraclean solution for disinfecting and agitate briefly. Leave to stand for 10 minutes.

Note: certain heart rate transmitter models should not be placed in solutions but rather gently disinfected with alcohol wipes. Please check the cleaning and disinfecting instructions for your transmitters prior to submerging in solution.

- 6 After 10 min, remove items from Viraclean and rinse under cold tap water.
- 7 Hang the heart rate monitor chest strap and transmitter on a drying rack and place the ear pieces on clean paper towel to dry.
- 8 Discard solutions unless there is the potential that others may use the Sonidet solution within the next 24 hours.

Cleaning and disinfecting of mouthpiece, nose clip and breathing tubes used in $\dot{V}O_{2\max}$, lactate threshold and maximally accumulated oxygen deficit (MAOD) testing

Mouthpiece and nose clip

- 1 Put on a pair of gloves.
- 2 Separate the mouthpiece components in the sink.
- 3 Rinse excessive sweat and saliva from the mouthpiece under cold tap water.

- 4 Place the mouthpiece and nose clip into prepared Sonidet solution. Gently agitate until clean and then rinse under cold tap water.
- 5 Place the mouthpiece and nose clip into prepared Viraclean solution for disinfecting and agitate briefly. Leave to stand for 10 minutes.
- 6 After 10 minutes, remove items from Viraclean and rinse under cold tap water. (NB: this step is especially important for the mouthpiece to avoid it 'tasting' like disinfection solution for the next participant.)
- 7 Allow the mouthpiece and nose clip to dry, preferably in a drying cabinet at 65–75°C to reduce the risk of re-contamination during assembly of the mouthpiece.[2]
- 8 Discard solutions unless there is the potential that others may use the Sonidet solution within the next 24 hours.

Breathing tube

- 1 Put on a pair of gloves.
- 2 Rinse excessive saliva from the breathing tube under cold tap water.
- 3 Place the breathing tube into prepared Sonidet solution. Gently agitate until clean and then rinse under cold tap water.
- 4 Place the breathing tube into prepared Milton solution for disinfecting and agitate briefly. Leave to stand for 30 minutes.
- 5 After 30 minutes, remove the breathing tube from the Milton solution. (NB: breathing tubes do not need to be rinsed.)
- 6 Place the breathing tube on a hanging rack to dry.
- 7 Discard solutions unless there is the potential that others may use the solution within the next 24 hours.

Note: you are responsible for cleaning and disinfecting all of the equipment you use. You should not leave your equipment soaking for others to finish. Leaving equipment in cleaning solution also has the potential to reduce the lifespan of the equipment.

WASTE DISPOSAL

It is particularly important that all waste be disposed of in the appropriate manner under health and safety guidelines.

- All sharps must be disposed of in a designated (puncture proof) medical/clinical sharps container. If you have used a sharp instrument then it is your responsibility to ensure it is properly disposed of. Do not leave sharp instruments sitting on a bench top where another individual may come into contact with them.
- All clinical waste that carries any risk of contamination (e.g. paper towel, gloves, wrapping foil from analyser chips) must be disposed of in the biohazardous waste container.

Interpretation, feedback and discussion

INTRODUCTION

The ability of an exercise scientist to follow a protocol that generates accurate, reliable and valid test results is usually only part of the overall task. In most situations the tester will be required to interpret the data and provide feedback to the participant. Furthermore, there should be an opportunity for the participant to discuss the feedback with the tester. Interpretation, feedback and discussion of the test and test results are generally more challenging than conducting the test. Numerous additional factors may arise during these processes that may require the exercise scientist to think quickly to respond in an appropriate manner. The following sections provide a number of steps to assist the tester in correctly interpreting the test results, providing quality feedback and suggestions on how a discussion with the participant can be optimised. Each practical contained within this manual also includes activities to practise these skills.

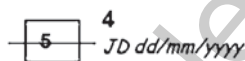
The participant usually expects to be provided with feedback immediately after a health and fitness test or testing session. This scenario of immediate verbal feedback will be used in the following discussion. It should be noted that there will also be situations where the tester will have more time to provide feedback to the participant in person and/or in a written form. For example, in many corporate health settings, different components of a health assessment may be conducted on separate occasions; the exercise scientist may then be required to collate all the data and provide both a written report and verbal feedback for the individual and the company.

DATA SHEET

In clinical research a great deal of emphasis is placed on the data sheet that contains the participant's information and test results. In research the data sheet is called a *case report form* or *CRF* and provides important guidelines for how data sheets in exercise and sports science testing should be used.[8] With the advent of technology there has been greater use of electronic data collection forms but most of the principles are still the same. To start with, it is vital that the data sheet is treated with the strictest of confidence. After it has been used to gather information on the participant it should be filed in a locked cabinet or room. If stored on a computer it should be password protected.

Other useful tips on completing the data form from the use of CRFs include:

- always use a black or blue pen for data recording on the data sheet (not a red pen or pencil)
- do not use any type of correction fluid (e.g. white-out). If a mistake is made draw a single line through the incorrect entry, place the correct answer near the box, and initial and date the correction as shown below:



- write down the value on the data sheet as soon as it has been collected (e.g. blood pressure during an exercise test). Relying on memory at the end of the test can be problematic.

EFFECTIVE COMMUNICATION

Effective communication between a practitioner and participant improves outcomes.[8, 9] Throughout the test it is important to communicate to the participant using words and phrases they can understand. Assessing a person's level of understanding is best done by asking open-ended questions at the start of the test (i.e. questions starting with how, what or why). For example, '*What do you know about the tests you are doing today?*'

A question similar to this should generate a response, leading to a discussion which will enable identification of the participant's literacy and health literacy levels (i.e., the ability to read, understand and use healthcare information to make decisions and follow instructions for treatment). This information

will enable the use of terminology and explanations during the session that are appropriate to the participant. These questions should also allow assessment of whether he/she has any anxiety about the tests. If this becomes apparent then every effort should be made to lessen these feelings.

To improve communication a useful skill is *active listening*. It is a structured way of listening and responding to others that improves mutual understanding.[10] It requires the tester to feed back what they hear to the participant. This can be done by restating or paraphrasing in their own words what they have heard.

Other important considerations:

- establish a physical environment that promotes good communication (e.g. private, opportunity to both sit down)
- do not allow external factors to distract attention from the participant
- make appropriate eye contact early in the session
- be aware of problems arising from differences in language and culture
- seek to understand the participant's expectations from the session
- if the participant has hearing and/or cognitive impairments, ensure instructions are explained slowly, clearly and at a volume which provides the participant with the best chance of understanding the directions and questions
- be sensitive or empathetic if the participant is sharing medical information
- a participant who is undertaking a number of tests at the same time (e.g. fitness test) may feel overwhelmed by all the information
- try not to speak in a condescending tone or simplify what is being said too much
- provide continuous opportunities for questions.

Being clear and concise, without using complicated medical or scientific terminology, is the best approach to effective communication in most situations.

INTERPRETATION

In this context, interpretation is referred to as the process of understanding the test results prior to providing feedback. In simple terms, interpretation is what is done before starting to talk to the participant or writing the report about the test results. The following steps should be used as a guide during this phase.

Step 1. Consider if the test provided meaningful results (i.e. should some or all of the test results be accepted)?

This will be based on questions such as:

- Was the protocol followed correctly?
- Does the data collected during the test appear accurate?
- When the data is compared to normative values does it still appear accurate?

These questions will often need to be answered by the tester in a short space of time and this can place significant stress on less experienced testers. At the end of this process the tester needs to decide whether the test, or part of the test, will be accepted and what specific feedback regarding the test results can be provided to the participant.

Step 2. How do the test results compare with normative values?

In Step 1 above, the normative values may have been looked at to decide whether the results are meaningful. In every situation it is essential that the normative data used for the comparison is appropriate to the individual being tested.

Finding appropriate normative data can often be difficult. In this manual normative data tables for the described tests have been provided where possible. The majority of these data have been collected on individuals similar to the expected users of this manual (men and women 18–25 years of age). Where the normative data provided within this manual is not relevant or is inappropriate to enable comparisons with the participant, the references provided at the end of the practical may be helpful to source additional normative data. If the plan is to provide immediate feedback to the participant then the appropriate normative tables should be sourced prior to testing and be available to make comparisons on completion of testing.

Step 3. Identify any health concerns (e.g. red flags)

In a number of testing situations measures may be made that indicate poor health (e.g. high blood pressure). The term 'red flag' is used to describe a warning sign that suggests referral to a health professional may be warranted. In appropriate practicals, the criteria for red flags are provided.

Step 4. Prepare for feedback

Where verbal feedback is to be provided to the participant then a plan of what is going to be said and the order in which it will be delivered should have been decided at the end of the interpretation phase, before starting to discuss the feedback with the participant.

FEEDBACK

Feedback is defined as a process where information is provided (fed back) with the aim of modifying a future action or behaviour, if needed.[11] Important elements of feedback in the exercise and sports science context are: (1) establishing a positive working relationship with the participant; and (2) ensuring the feedback is constructive. The definition of feedback is important as it separates the first component of explaining the test results with the second element of relating how the test result could be improved (if needed) or maintained. This section will deal primarily with verbal feedback and it is suggested to further divide this feedback regarding a test into three steps, that can be given the acronym **ESC**: explain the test; state the result/s; can the results be maintained or improved.

Step 1. Explain the test

What the test is and why it is being measured should have been explained prior to testing, however, it is useful to restate when providing feedback. Why the participant is having the test conducted should have also been determined. This will help to provide feedback that is relevant to the participant's circumstances. Where measures are being made as part of a fitness test, then knowing what the participant's health/fitness goals are will help to contextualise the test explanation. For example, if providing feedback on blood pressure and the participant indicates their wish to 'improve their health' you could use the word 'health' when providing feedback on these values. For example:

As part of the fitness test we measured your resting blood pressure as this is an important indicator of the overall health of your cardiovascular system.

During this step it may be appropriate to point out the *accuracy and limitations of the test*. This may not need to be done in all situations. For example, when conducting a fitness test that has multiple components it may not be necessary to explain the accuracy and limitations of each test. If it is considered appropriate to discuss the limitations of a test then it is important to avoid being too negative about the test. After all, the participant may have just completed some relatively hard exercise and they should not hear afterwards that the test may not be that accurate. A good example is the submaximal test for estimating cardiorespiratory fitness. If the protocol is followed, and assumptions met, the test can provide accurate $\dot{V}O_{2\max}$ predictions. However, most exercise scientists have experienced situations where the test does not provide a meaningful value. Which of the following two ways of providing feedback would be more effective in ensuring the participant trusts your ability to select and conduct the test, and potentially modify their behaviour based on the test result?

You completed a submaximal fitness test which provides an estimate of your aerobic fitness. The test is not that accurate as it has a lot of limitations but it looks like it has provided a score that is close to what I expected ...

You completed a submaximal fitness test which provides an estimate of your aerobic fitness. The test has some limitations but as we have closely followed the protocol we have an accurate result ...

Step 2. State the result/s including qualitative wording

It is important that the tester provides the participant with their test result (e.g. value) and how that compares with normative values. Following a test the participant may be provided with a lot of numbers. During a typical fitness test the person could be told that:

your resting heart rate is 72 bpm, blood pressure is 130 over 90 mmHg, BMI is 29 kg/m², body fat percentage is 27%, grip strength is 45 kg, flexibility is 12 cm and your estimated $\dot{V}O_{2\max}$ is 32 mL/kg/min.

How many of these numbers will the participant be able to take in and remember? Likely very few, if any. For this reason it is vital that written feedback is also provided that contains these data. More important (and more memorable) to the individual will be the qualitative words that should be used in addition to the numerical data.

This stage of the feedback is where any health implications of the data should be conveyed. For example, low cardiorespiratory (aerobic) fitness, overweight or obesity and low muscular strength all have important health implications. If any test results are a 'red flag' then a discussion regarding a referral to the appropriate health professional (usually the participant's general practitioner) should occur. However, as explored further in the next step, care needs to be taken to maintain a constructive environment during this part of the feedback process.

Step 3. Can the results be maintained or improved?

This is generally the hardest part of the feedback stages. Can the test result/s be improved? Does the participant want/need improvement/s? An understanding of exercise science should help in answering the first question; understanding the reason why the person is having the test conducted will help answer the second.

It may be useful to suggest monitoring of any areas of concern with follow-up testing planned for set times in the future. However, it is essential to know what the expected timeframes are for changing exercise test parameters (e.g. how long it will take to lose a certain amount of fat/mass/waist circumference).

This stage of feedback can also allow an opportunity to reflect on the constructive aspects of the process. Undergoing exercise and health tests can be a negative experience for the participant. For some individuals, explaining that their health or fitness is in a poor state may be what is needed to encourage them to start changing their behaviour. However, psychology research has shown that creating a constructive, supportive environment is more likely to be beneficial for behaviour change in the majority of people.[12] This doesn't mean that poor test results should not be conveyed to the participant. The goal is to do it in such a way that promotes a constructive feel about the whole process. For example:

Your body fat percentage and BMI places you in the obese category and your aerobic fitness is very low for someone of your age and sex. We know that being unfit and overweight increases your risk of diseases such as heart disease and diabetes. It is great that we now know what these values are because I can write you an individualised program that will improve your fitness and assist you to lose the weight. We can also remeasure these values in a few months to see how much you are improving.

DISCUSSION

When providing feedback, it is important to gain an understanding of the participant's thoughts, feelings and concerns and then respond to these empathetically. The participant should be encouraged to ask questions or discuss the test and/or test results throughout the whole process (see effective communication above). The tester should make a statement at the start of the session to encourage the participant to ask questions or make comments throughout to ensure they fully understand the results. In addition, it is important to allow time at the end of the session for the participant to ask any remaining questions about any of the results or questions regarding their health concerns.

Considering the range of tests that are conducted in exercise and sports science settings the questions could cover a wide theoretical range. It is likely that some questions will fall outside of the tester's knowledge. In these situations it is vital that guesses are not made. If the guessed answer is incorrect this can lead to the participant adopting a behaviour that is unnecessary or a belief that is wrong. The tester should state that *'I am sorry I don't know'* and if possible *'I will find out and get back to you with the answer'*. Examples where this is common is when a participant has a medical condition, or is taking a drug or supplement and they question whether this has affected one of the test results. Unless the tester is certain of the answer they should not guess. In these situations it may be suggested that the participant discuss this with their general practitioner.

REFERENCES

- [1] Commonwealth of Australia. Hand Hygiene Australia. 5 Moments for Hand Hygiene.2009 July[cited March 2012]; Available from: [http://www.hha.org.au/UserFiles/file/Manual/ManualJuly2009v2\(Nov09\).pdf](http://www.hha.org.au/UserFiles/file/Manual/ManualJuly2009v2(Nov09).pdf)
- [2] Queensland Health. Disinfection and Sterilization. Infection Control Guidelines.2008[cited March 2012]; Available from: www.health.qld.gov.au/chrisp/sterilising/large_document.pdf

- [3] Whiteley Medical. Sonident Technical Bulletin.[cited March 2012]; Available from: www.whiteley.com.au/DownloadDocument.aspx?documentId=112
- [4] Whiteley Medical. Viraclean Technical Bulletin.[cited March 2012]; Available from: <http://whiteley.com.au/Product/Viraclean_68>
- [5] Whiteley Medical. Material Safety Data Sheet: Viraclean.[cited March 2012]; Available from: <http://www.westcoastsurgical.com.au/resources/msds_Viraclean-9.pdf>
- [6] Procter and Gamble UK. Milton 2% for hospital use - Dilution chart.[cited March 2012]; Available from: <http://www.milton-tm.com/hres/clinical%20use%20dilution%20chart.pdf>
- [7] Milton Pharmaceutical Company UK Limited. Safety Data Sheet.2004[cited March 2012]; Available from: <http://www.milton-tm.com/downloads.html>
- [8] International Clinical Sciences Support Center. Case report form development. 2012.
- [9] Stewart MA. Effective physician-patient communication and health outcomes: A review. CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne. 1995;152:1423-33.
- [10] Klagsbrun J. Listening and focusing: Holistic healthcare tools for nurses. Nurs Clin North Am 2001;36: 115–30.
- [11] Thomas JD, Arnold RM. Giving feedback. J Palliat Med 2011;14:233–9.
- [12] London M. Giving feedback: Source-centered antecedents and consequences of constructive and destructive feedback. Hum Resour Manage R 1993;5:159–88.

Practical 4

Anthropometry

Tina Skinner, Gary Slater and Kellie Pritchard-Peschek

Learning objectives

- Demonstrate an understanding of the anatomical basis, terminology, application, assumptions, limitations and protocol considerations of anthropometry
- Perform basic anthropometry and bioelectrical impedance analysis
- Calculate inter- and intra-tester variability
- Interpret anthropometry results and provide feedback to a participant

Equipment and other requirements

- Information sheet and informed consent form
- Skinfold calipers
- Self-retracting, flexible metal anthropometry tape
- Marker pen
- Alcohol swabs
- Segmometer
- Anthropometry box (dimensions 40 cm x 50 cm x 30 cm)
- Stadiometer (wall-mounted or portable)
- Body mass scales
- Bioelectrical impedance analysis (BIA) device
- Calculator

INTRODUCTION

Assessment of physique traits by exercise and sport scientists and accredited exercise physiologists are routine measurements, with applications across a broad range of situations, including:

- general health screening tool in lifestyle-related disease risk assessment
- monitoring the effectiveness of lifestyle (i.e. diet and/or exercise) or other (e.g. pharmacological or surgical) interventions
- assessing long-term change in body composition
- talent identification within the sporting environment.

A wide array of techniques are available for the measurement of physique traits, including anthropometric, radiographic (computed tomography (CT), dual energy x-ray absorptiometry (DXA)) and other medical imaging techniques (magnetic resonance imaging (MRI), ultrasound), metabolic (creatinine, 3-methylhistidine), nuclear (total body potassium, total body nitrogen) and bioelectrical

impedance analysis (BIA) techniques. When selecting the most appropriate technique, a range of factors should be considered, including technical issues such as the safety, validity, precision and accuracy of measurement. Practical issues must also be considered such as equipment availability, financial implications, portability, invasiveness, time effectiveness, and technical expertise necessary to conduct the procedures. Consideration must also be given to the ability of physique trait assessment methodologies to accommodate the unique body composition characteristic of some participants, including particularly tall, broad, and muscular individuals or those with extremely high or low body fat levels.

Practical 4 reviews the use of surface anthropometry and indices of heaviness (including scale weight as well as body mass index (BMI)) as these are the most commonly used techniques to assess the physique traits of the majority of participants.

Definitions

Body mass index (BMI): a population-based measure of obesity-related disease risk calculated as body mass (in kilograms) divided by height (in metres) squared (kg/m^2).

Frankfort plane: position of the head when the orbitale (lower edge of the eye socket) is in the same horizontal plane as the tragon (the notch superior to the tragus of the ear).

Index of central obesity (ICO): also known as waist-to-height ratio, this is a population-based measure of central obesity and obesity-related disease risk calculated as waist circumference (in centimetres) divided by height (in centimetres).

Inter-tester variability: also known as between-tester variability, this is the amount of agreement (variability) between two different testers measuring the same parameter on the same individual.

Intra-tester variability: also known as within-tester variability, this is the amount of agreement (variability) from the same tester measuring the same parameter on different occasions.

Mid-prone position: the participant assumes a relaxed standing position with the arm hanging by the side and the thumb pointing forward.

Reliability: the reproducibility of a measurement.

Activity 1 Body mass index

AIM: measure height (stretch stature) and body mass to classify obesity-related disease risk within an adult population, interpret the results and provide feedback to a participant.

BACKGROUND

A strong association exists between lifestyle, disease risk and overweight or obesity. Specifically, the central distribution of body fat significantly increases the risk of a range of diseases, including type 2 diabetes mellitus, hypertension and hyperlipidemia.[1] The BMI measure was developed to classify obesity-related disease risk within populations. However, it is used extensively to interpret the body composition of individuals using population-based category ranges. This is a significant limitation and caution should be taken when interpreting individual results from a test designed for population-based assessment. It is recommended that individual BMI results not be interpreted in isolation; that is, if a participant's BMI is calculated, feedback should only be provided in combination with other measures of physique traits.

Body mass can be acutely influenced by an array of factors, independent of changes in fat mass or skeletal muscle mass. Adults can exhibit diurnal variation of approximately 1% in stature and 2 kg in body mass over the course of the day.[2,3] Consequently, body mass measurements should be made at the same time of day (preferably upon waking, before breakfast or training but after voiding the bladder and bowel) or at least the same time of day when serial measurements are performed over time and wearing minimal clothing,[4] so as to minimise the influence of extraneous factors that can impact on body mass. Other issues to consider to improve the accuracy of body mass measurements include consistency in the scales used,[5] the phase of the menstrual cycle in females[6] and hydration status.

When BMI cut-offs are applied at an individual level, a number of assumptions are made that may result in inappropriate classification of disease risk. For example, there is no distinction between the composition of total body mass, thus muscular athletes are often categorised at an increased disease risk due to their higher body mass relative to their height. As such, BMI is best combined with a measure of body fat distribution such as a waist girth, waist-to-hip ratio or index of central obesity, as this more accurately describes disease risk.[7]

PROTOCOL SUMMARY

Measure the participant's height and body mass in duplicate (or triplicate as required), dividing the mass in kilograms by the height in metres squared to determine BMI.

PROTOCOL

Stature (stretch)

- 1 Follow the pre-test requirements described in Appendix A.
- 2 Ask the participant to remove his/her shoes.
- 3 The participant then stands directly under the stadiometer with their feet together and their heels, buttocks, and upper part of their back touching the wall or the stadiometer.
- 4 The participant's head should be positioned in the Frankfort plane. The Frankfort plane is achieved by placing the tips of the thumbs on each orbitale, and the index fingers on each tragon, then horizontally aligning the two. You then relocate your thumbs posteriorly towards the participant's ears, and far enough along the line of the jaw to ensure that upward pressure, when applied, is transferred through the mastoid processes (Figure 4.1).



Figure 4.1 Application of upward pressure through the mastoid processes for measurement of stretch stature

- 5 Instruct the participant to take in and hold a deep breath while keeping the head in the Frankfort plane.
- 6 Apply a gentle upward lift through the mastoid processes.
- 7 The recorder brings the stadiometer tape down until it is placed firmly on the vertex, crushing the participant's hair as much as possible. Ensure that the heels do not leave the floor and that the position of the head is maintained in the Frankfort plane.
- 8 Depending on the stadiometer, it may be helpful for the tester to stand on an anthropometry box so the reading is made at eye level.
- 9 The measurement is taken at the end of a deep inward breath.

Body mass

- 1 Follow the pre-test requirements described in Appendix A.
- 2 The bladder should be voided prior to assessment.
- 3 Position the scales where you will be able to read the dial clearly and directly from the front (i.e. reading the dial upside down) [Figure 4.2].



Figure 4.2 Positioning of head directly over the scales to avoid parallax error when measuring body mass

- 4 Calibrate the scales to ensure they are reading zero.
- 5 The participant should be dressed in minimal clothing with shoes removed and pockets emptied.
- 6 Ask the participant to stand on the centre of the scales without support and with the body mass evenly distributed on both feet.
- 7 Ask the participant to hold their head up and look directly ahead.
- 8 When the body mass measure stabilises, record the result.

DATA ANALYSIS

Perform measures for two rotations (trial 1 and trial 2) of height and body mass. If there is $\leq 1.5\%$ difference between the two measures (i.e. trial 1 height vs trial 2 height; trial 1 body mass vs trial 2 body mass), record the mean (average) of these measures. If there is $> 1.5\%$ difference between the two measures, perform a third measure and record the median. To calculate whether your measures are $\leq 1.5\%$:

$$\text{Calculating accuracy} = \left[\frac{\text{largest measure} \times 100}{\text{smallest measure}} \right] - 100$$

Data recording				
Participant: _____		Date: _____		Age: _____ (y) Sex: M / F
Measure	Trial 1	Trial 2	Trial 3 (If required) ^a	Mean or median ^b
Height (cm)				
Body mass (kg)				

Calculate BMI using the mean/median of body mass and height in the equation:

$$\text{BMI} = \text{body mass (kg)} / \text{height}^2 \text{ (m)}$$

$$\text{BMI} = \text{_____ kg/m}^2$$

Classification (according to Table 4.1): _____

Risk of obesity-related diseases from BMI and waist circumference (according to Table 4.1):

Table 4.1 Combining BMI and waist circumference to define lifestyle-related disease risk in adults

BMI		WAIST CIRCUMFERENCE (cm)	
Classification	(kg/m ²)	Male (94–102 cm) Female (80–88 cm)	Male (102+ cm) Female (88+ cm)
Underweight	<18.5	—	—
Normal weight	18.5–24.9	—	Increased*
Overweight	25.0–29.9	Increased*	High*
Obese	30.0–34.9	High*	Very high*

*Risk of obesity-related diseases (e.g. diabetes, hypertension and cardiovascular disease)

Note: the waist circumference norms presented above are for Adult Caucasians.

Source: National Health and Medical Research Council[1]

INTERPRETATION, FEEDBACK AND DISCUSSION

Consider the 4 steps of interpretation located in the 'interpretation, feedback and discussion' section at the start of this manual and refer to Table 4.1 to classify obesity-related disease risk within an adult population (i.e. 21 years or older). For individuals <21 years of age, BMI-for-age percentile charts should be used (Figures 4.3 and 4.4). Amongst elderly populations, all-cause mortality is not increased until BMI reaches the obese range[8] with evidence of elevated risk at a BMI below 25 kg/m²[2,9]. Evidence suggests the association between BMI, body fat and fat distribution differ across ethnic groups. As such, population-specific cut-off points for BMI have been proposed[10]; including a lowering of cut-offs to define overweight and obesity for Asian populations.[11] While it has been suggested that BMI cut-offs should differ for individuals of Polynesian descent due to their relatively higher proportion of lean body mass for a given BMI, this has been recently refuted.[12]

^aTake a third measure if the difference between trials 1 and 2 differ by >1.5%.

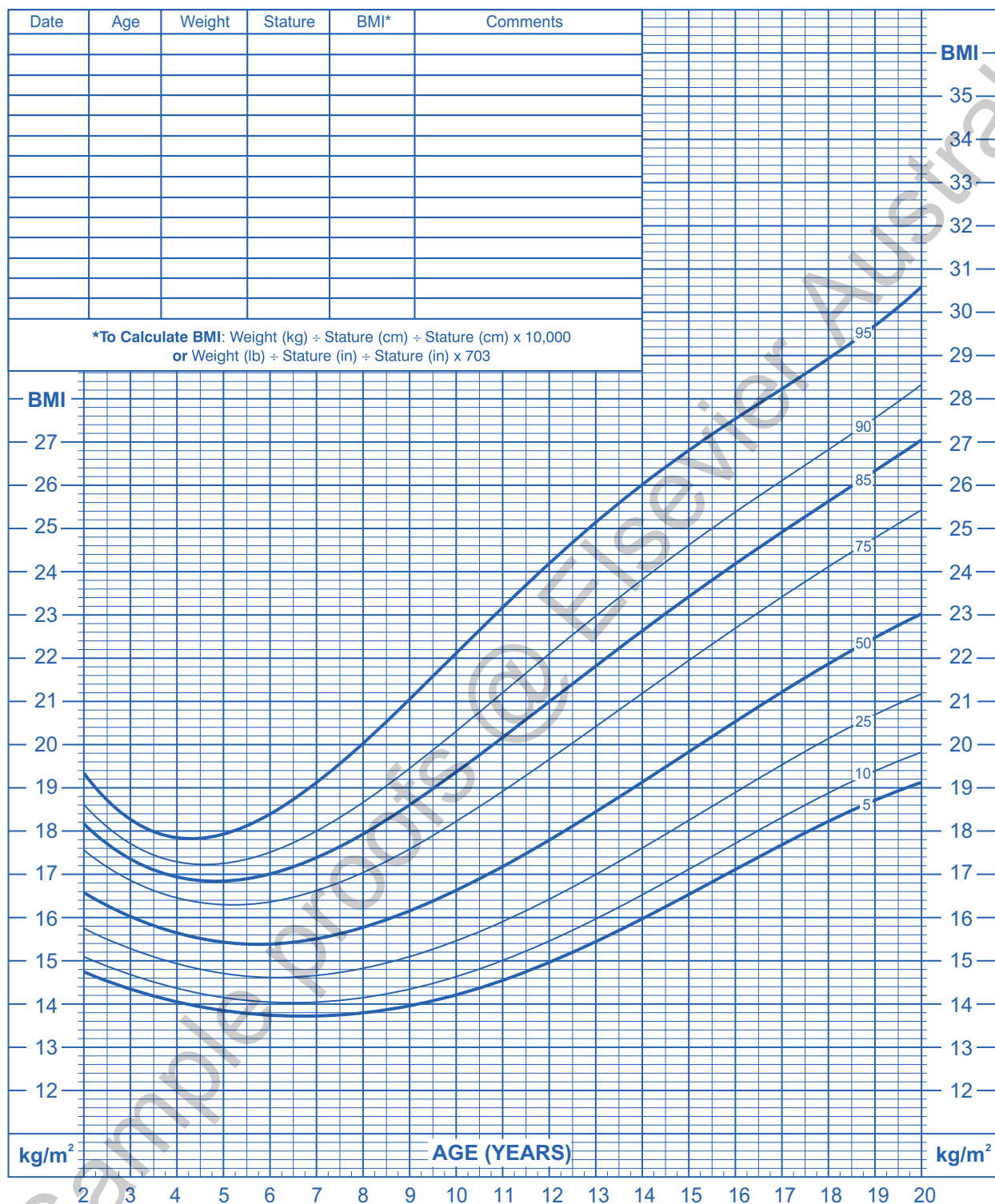
^bRecord the mean if only two measures are taken. Record the median if three measures are taken.

2 to 20 years: Boys

Body mass index-for-age percentiles

NAME _____

RECORD # _____



Published May 30, 2000 (modified 10/16/00).

SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000). <http://www.cdc.gov/growthcharts>



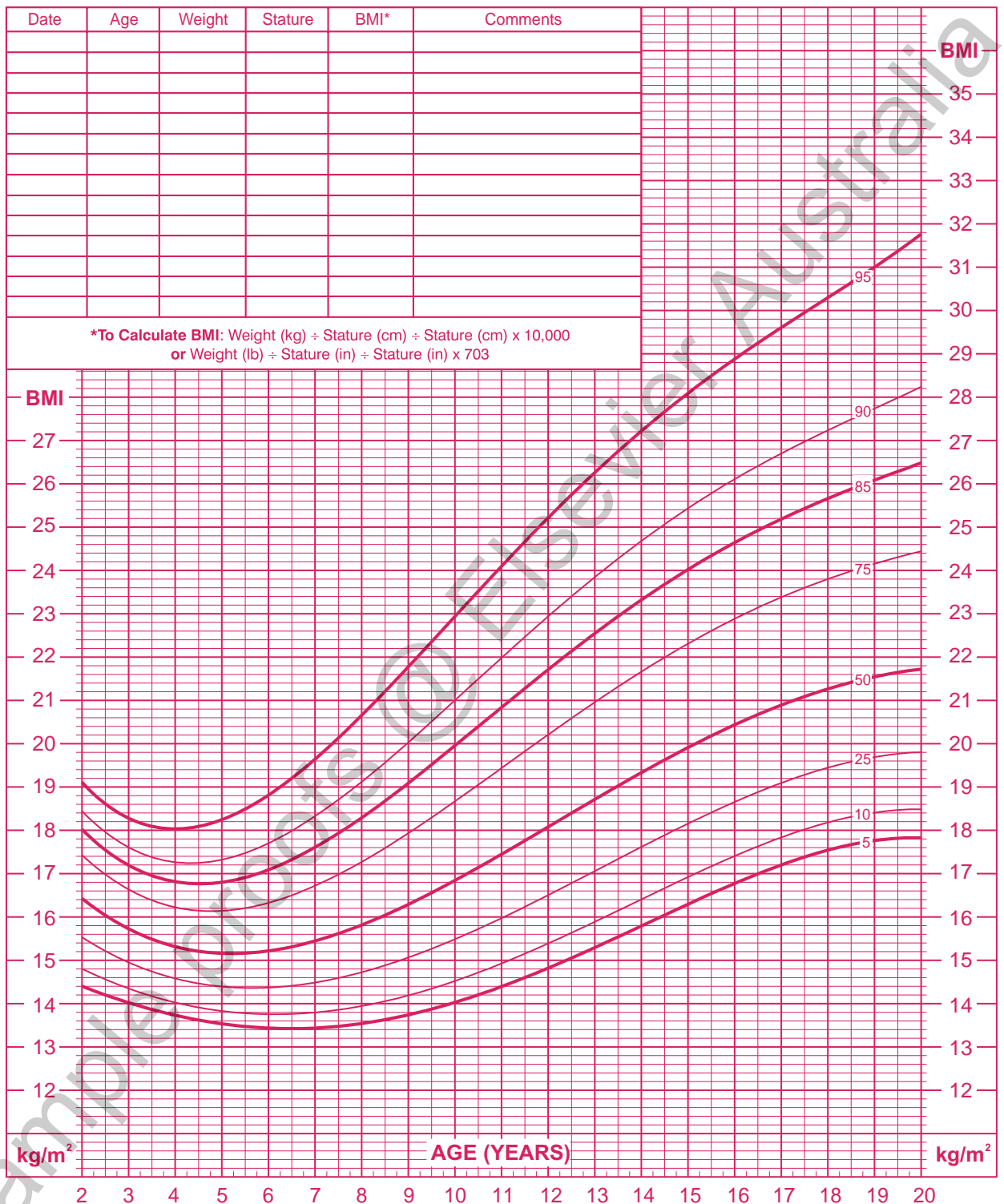
SAFER • HEALTHIER • PEOPLE™

Figure 4.3 Girls: body mass index-for-age percentiles

2 to 20 years: Girls Body mass index-for-age percentiles

NAME _____

RECORD # _____



Published May 30, 2000 (modified 10/16/00).
SOURCE: Developed by the National Center for Health Statistics in collaboration with
the National Center for Chronic Disease Prevention and Health Promotion (2000).
<http://www.cdc.gov/growthcharts>

Figure 4.4 Boys: body mass index-for-age percentiles

Factors to consider:

- How would the participant react to being labelled within one of the BMI categories (i.e. would categorising your participant as 'underweight' or 'obese' be beneficial or detrimental)?
- Does the participant appear to have a large amount of muscle mass that may have influenced the results (e.g. resistance-trained athletes)?
- Is the participant involved in sporting or other activities in which a higher BMI (e.g. Sumo wrestling) or lower BMI (e.g. runway modelling) may be beneficial?

Most participants will generally be aware of their BMI category even before you conduct the test. Most obese individuals will be aware that they are obese, yet hearing that they are obese may be a negative experience. Therefore, delivering the results will require sensitivity and tact to ensure that the feedback and discussion is a positive and productive experience.

For participants who have a large muscle mass for which you believe that the results may not reflect their actual risk of obesity-related diseases, highlighting the limitations of BMI to differentiate between muscle mass and fat mass will be important. For participants whose performance is dependent on higher or lower BMI, the feedback and discussion should focus around this, however, it may still be important to ensure that the participant is aware of their risk of obesity-related diseases.

Activity 2 Girths

AIM: measure waist and hip circumferences to classify obesity-related disease risk within an adult population, interpret the results and provide feedback to a participant.

BACKGROUND

Waist and hip circumferences can be used as a measure of body fat distribution. Higher values of waist relative to hip circumference indicate greater adiposity in the abdominal region (android or 'apple' shape), whilst lower values indicate greater adiposity in the hip and gluteal region (gynoid or 'pear' shape). Android obesity is associated with an increased risk of cardiovascular disease (CVD).

PROTOCOL SUMMARY

Measure the participant's waist and hip circumferences in duplicate (or triplicate as required), dividing the waist by the hip circumference to determine waist-to-hip ratio.

PROTOCOL

Follow the pre-test requirements described in Appendix A and 'general methods for measuring girths' in Table 4.2.

Waist circumference

Definition: the circumference of the abdomen at its narrowest point between the lower costal (10th rib) border and the top of the iliac crest, perpendicular to the long axis of the trunk.

Location: ask the participant to fold their arms across their chest with their hands on opposite shoulders. Stand in front of the participant and pass the tape around the abdomen. The stub of the tape and the housing are then both held in the right hand while using the left hand to adjust the level of the tape at the back to the adjudged level of the narrowest point. Resume control of the stub with the left hand using the cross-hand technique and position the tape in front at the target level

Table 4.2 General methods for measuring girths

1. Have the participant assume the necessary position for each girth measurement, making use of an anthropometric box where appropriate to ensure the tester's eyes are at the level of the site being measured.
2. Employ the 'cross-hand' technique by holding the case of the tape in the right hand and stub in the left. Feed the stub of the tape measure in a clockwise direction around the participant. Gauge whether you may have difficulties reading all the way around your participant's waist, and if so, ask the participant to hold one end of the tape whilst you walk the other end around their waist.
3. Secure the stub and case with the right hand to allow the left hand to manipulate the tape. When the tape has been positioned correctly, regain control of the stub in the left hand by reaching underneath the right hand.
4. Where possible, measurements should be taken from the participant's right side, ensuring you remain outside of the participant's personal space.
5. The tape is to be held at right angles to the long axis of the body segment being measured, with the tape manipulated so the zero marking can be read laterally. The middle fingers can be used to further manipulate the tape.
6. Once in place regain control of the stub in the left hand by reaching underneath the right hand. The right hand is always above the left hand, ensuring the zero marking on the tape can be aligned with the millimetre notches that appear on the bottom of the tape (Figure 4.5). Allow the tape to self-retract, maintaining constant tension sufficient to minimise gaps between skin and tape but not so much that there is any compression of the underlying skin and subcutaneous tissue.
7. Ensure there is sufficient space between the fingers and thumb from the zero mark and read the girth with eyes level to tape.



Figure 4.5 Anthropometry tape showing free end of tape aligned with millimetre notches on the bottom



Figure 4.6 Waist circumference

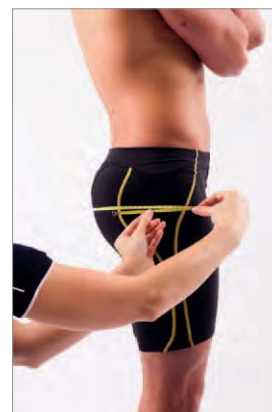


Figure 4.7 Gluteal (hip) circumference

(Figure 4.6). The participant should breathe normally and the measurement is taken at the end of a normal expiration (end tidal). If there is no obvious narrowing the measurement is taken at the mid-point between the lower costal (10th rib) border and the iliac crest.

Gluteal (hip) circumference

Definition: the circumference of the buttocks at the level of the greatest posterior protuberance, perpendicular to the long axis of the trunk.

Location: ask the participant to stand with their feet together, the gluteal muscles relaxed and rest their hands on their opposite shoulders. Stand to the right of the participant and pass the tape around the hips from the side. The stub of the tape and the housing are then both held in the right hand while the left hand adjusts the level of the tape at the back to the level of the greatest posterior protuberance of the buttocks. Resume control of the stub with the left hand and using the cross-hand technique position the tape at the side (Figure 4.7). Double-check with the recorder that the tape is in a horizontal

plane at the target level, before taking the measurement. If the participant is wearing thick clothing (jeans etc.) pull the tape measure very slightly to compress any clothing.

DATA ANALYSIS

Perform the girth measures for two rotations (trial 1 and trial 2) of the waist and gluteal (hip). If there is $\leq 1.5\%$ difference between the two measures (trial 1 waist circumference vs trial 2 waist circumference; trial 1 hip circumference vs trial 2 hip circumference), record the mean (average) of these measures. If there is $> 1.5\%$ difference, perform a third measure and record the median of the three values. To calculate whether your measures are $\leq 1.5\%$:

$$\text{Calculating accuracy} = \left[\frac{\text{largest measure} \times 100}{\text{smallest measure}} \right] - 100$$

Data recording				
Participant: _____		Date: _____		Age: _____ (y) Sex: M / F
Measure	Trial 1	Trial 2	Trial 3 (If required) ^c	Mean or median ^d
GIRTHS				
Waist (cm)				
Gluteal (hip) (cm)				

Waist circumference = _____ cm

Risk of obesity-related diseases from waist circumference (according to Table 4.3): _____

Table 4.3 Risk criteria for waist circumference in adults

RISK CATEGORY*	MALES (cm)	FEMALES (cm)
Very low	<70	<80
Low	70–89	80–99
Moderate	90–109	100–120
High	>110	>120

*Risk of obesity-related diseases (e.g. diabetes, hypertension and cardiovascular disease).

Source: Bray[13]

Calculate waist-to-hip ratio (WHR) using the mean/median of waist and hip circumferences in the equation:

$$\text{WHR} = \text{waist circumference (cm)} / \text{hip circumference (cm)}$$

$$\text{WHR} \text{ _____ kg/m}^2$$

Risk of obesity-related diseases from WHR (according to Table 4.4): _____

^cTake a third measure if the difference between trials 1 and 2 differs by $> 1.5\%$.

^dRecord the mean if only two measures are taken. Record the median if three measures are taken.

Table 4.4 Waist-to-hip ratio to define lifestyle-related disease risk in adults

RISK CATEGORY*	MALES		FEMALES	
	<60 years	>60 years	<60 years	>60 years
Low	<0.90	<0.95	<0.80	<0.85
Moderate	0.90–0.95	0.95–1.03	0.80–0.86	0.85–0.90
High	>0.95	>1.03	>0.86	>0.90

*Risk of obesity-related diseases (e.g. diabetes, hypertension and cardiovascular disease).
Source: adapted from Folson,[14] and Heyward & Stolarczyk[15]

Calculate waist-to-height ratio using the mean/median of waist circumference and height in the equation:

Waist-to-height ratio = waist circumference (cm) / height (cm)

Waist-to-height ratio: _____

Waist-to-height ratio risk stratification: _____

INTERPRETATION, FEEDBACK AND DISCUSSION

Consider the 4 steps of interpretation located in the 'interpretation, feedback and discussion' section at the start of this manual. Disease risks associated with waist circumferences for both males and females are specified in Table 4.3, whilst the disease risks when both BMI and waist circumference data are combined are found in Table 4.1. Use Table 4.4 to classify WHR.

A waist-to-height ratio, also known as the index of central obesity (ICO), of 0.5 or more indicates increased health risk, independent of gender, ethnicity and possibly age.[16]

When providing feedback to the participant it is encouraged that multiple assessments of body composition (e.g. BMI, WHR, waist circumference and skinfolds) are combined to provide a more comprehensive overview of their current disease risk and minimise the limitations of each individual test. For example, providing feedback on WHR in isolation will provide a good indication of the participant's relative body fat distribution, however will not provide any absolute measure of fat mass. A participant may be at 'low risk' when classifying their waist relative to their hip circumference, however their actual waist circumference may classify them at an increased risk of obesity-related diseases. Providing this information independently may confuse the participant.

Activity 3 Inter- and intra-tester variability

AIM: to calculate inter- and intra-tester variability.

BACKGROUND

All tests within health, sport and physical assessment contain measurement error. It is important to determine whether testers are being consistent in their measurements and the amount of error between measurements. Calculation of inter- and intra-tester variability enables greater confidence in the accuracy of the results and the ability to detect meaningful changes.

PROTOCOL SUMMARY

Measure waist and hip circumferences on multiple occasions to calculate inter- and intra-tester variability.

PROTOCOL

Working in a group of three, each individual performs waist and hip circumferences on the other two group members. On another occasion (e.g. 1 week later) repeat these procedures. Ensure the same person is measured twice (with 1 week between measures) and have two group members take measurements on the same person (with 1 week between measures).

DATA ANALYSIS

Record your data from two different testers (tester 1 and tester 2) with one week between the measures. To calculate inter-tester variability you need to be measured by two different testers.

Data recording				
Participant: _____ Date: _____ Age: _____ (y) Sex: M / F				
Inter-tester variability: week 1				
Week 1: tester 1 name: _____				
Measure	Trial 1	Trial 2	Trial 3 (If required) ^e	Mean or median ^f
GIRTHS				
Waist (cm)				
Gluteal (hip) (cm)				
WHR from tester 1: _____				
Inter-tester variability: week 2				
Week 2: tester 2 name: _____				
Measure	Trial 1	Trial 2	Trial 3 (If required) ^e	Mean or median ^f
GIRTHS				
Waist (cm)				
Gluteal (hip) (cm)				
WHR from Tester 2: _____				
$\text{Inter-tester variability} = \left[\frac{\text{largest measure} \times 100}{\text{smallest measure}} \right] - 100$				
Inter-tester variability: _____ %				
Intra-tester variability: week 1				
Participant's name: _____				

^eTake a third measure if the difference between trials 1 and 2 differs by >1.5%.

^fRecord the mean if only two measures are taken. Record the median if three measures are taken.

Data recording <i>(continued)</i>				
Measure	Trial 1	Trial 2	Trial 3 (If required) ^g	Mean or median ^h
GIRTHS				
Waist (cm)				
Gluteal (hip) (cm)				
WHR from Trial 1: _____				
Intra-tester variability: week 2				
Measure	Trial 1	Trial 2	Trial 3 (If required) ^g	Mean or median ^h
GIRTHS				
Waist (cm)				
Gluteal (hip) (cm)				
WHR from Trial 2: _____				
$\text{Inter-tester variability} = \left[\frac{\text{largest measure} \times 100}{\text{smallest measure}} \right] - 100$				
Intra-tester variability: _____ % Within acceptable range? Y/N				

INTERPRETATION, FEEDBACK AND DISCUSSION

The International Society for the Advancement of Kinanthropometry (ISAK) supply proposed targets that are determined from measurements collected on 20 different people on different days.

The recommended inter-tester variability is 10% for skinfold measurement, and 2% for other measures (i.e. girth and breadth measurements).[17]

The acceptable range for the intra-tester variability measurements according to ISAK is 7.5% for skinfolds, and 1.5% for the girth and breadth measures.[17]

The higher the inter- or intra-tester variability measurements, the lower the confidence in the accuracy of the results and the ability to detect meaningful changes. If the recorded inter- or intra-tester variability measurements are significantly greater than the ISAK proposed targets, completion of an ISAK anthropometry course and/or additional practice is recommended.

Activity 4 Surface anthropometry

AIM: to measure subcutaneous skinfold thicknesses at specific anatomical landmarks, interpret the results and provide feedback to the participant.

BACKGROUND

Among population groups such as athletes or the obese, consideration must be given to the unique physique traits these individuals may possess, including particularly tall, broad and/or muscular

^gTake a third measure if the difference between trials 1 and 2 differs by >1.5%.

^hRecord the mean if only two measures are taken. Record the median if three measures are taken.

individuals as well as those with very low or high body fat levels. These factors considered together, *surface anthropometry* continues to be utilised for the routine monitoring of body composition, although *bioelectrical impedance analysis (BIA)* *dual-energy x-ray absorptiometry (DXA)* are becoming more popular as their accessibility increases.

For reasons of timeliness, practicality and cost effectiveness, the routine monitoring of body composition is most often undertaken using anthropometric measurement of body mass, subcutaneous skinfold thicknesses and girths at specific anatomical landmarks. Surface anthropometry requires relatively inexpensive equipment that is easily portable (Figure 4.8). Aside from the convenience of surface anthropometry for assessing physique traits, parameters such as skinfolds are very robust, and not readily influenced by factors such as hydration status.[18] However, skilled technicians are required if accurate and reliable data are to be collected, and it is important that the same technician collect the data.[19]

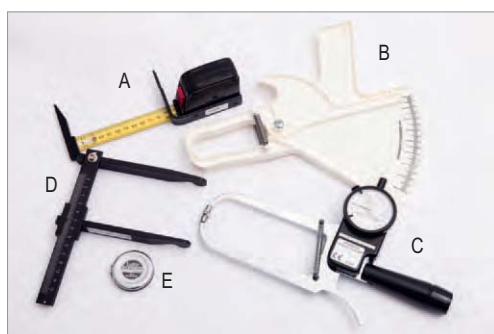


Figure 4.8 Surface anthropometry equipment — A, segmometer; B and C, calipers; D, small bone calipers; E, anthropometry tape

Precise assessment of anthropometric traits, in particular skinfold thickness, can be difficult and therefore extreme care in site location and measurement is required if meaningful results are to be obtained. Prior to assessment, the tester should develop the appropriate technique, reducing the level of error in repeated measurements, and thus enhancing the ability to detect small but potentially important changes. The standard assessment protocol of the International Society for the Advancement of Kinanthropometry (ISAK)[17] is recommended. Testers wishing to monitor the physique traits of individuals using surface anthropometry are strongly encouraged to undertake professional training through accredited courses.

The measurement of 'skinfolds' refers to the thickness of a double fold of skin and compressed subcutaneous adipose tissue.[20] To infer fat mass (FM) or percentage of total body fat from skinfold measurement requires a number of assumptions to be made, including:

- constant compressibility of skinfolds across sites on the body
- the skin thickness at any one site is negligible or a constant fraction of a skinfold
- fixed adipose tissue patterning across the body.

While it is estimated that subcutaneous fat comprises one-third of total body fat, this can range from 20–70% depending on sex, degree of fatness, age and fitness.[21] Despite the obvious flaws in these assumptions, a strong relationship does exist between subcutaneous adiposity and whole body adiposity, and between direct skinfold thickness measures and whole-body adiposity.[22]

PROTOCOL SUMMARY

Identify and mark specific anatomical landmarks on the participant's body before measuring and recording the subcutaneous skinfold thickness at each site.

PROTOCOL

The following protocol for the use of surface anthropometry has been developed by ISAK. It relates specifically to the measurement of subcutaneous fat thickness via the use of skinfold measures. The reader is directed elsewhere for details on the procedure for other measures such as lengths and breadths.[23]

Follow the pre-test requirements described in Appendix A and general methods for landmarking in Table 4.5.

Table 4.5 General methods for landmarking

1. Where possible, all sites should be marked and measured on the right side of the body.
2. Identify landmark with thumb or index finger.
3. Release the site to remove skin distortion.
4. Mark with a fine pen directly over site.
5. Landmarks are marked with a small horizontal line (–) while skinfold sites are marked with a small cross (+).
6. Re-check.
7. Mark all sites before measuring.

1. Acromiale

Definition: the point on the superior aspect of the most lateral part of the acromion border.

Location: stand behind and on the right side of the participant and palpate along the spine of the scapula to the corner of the acromion. This represents the start of the lateral border which usually runs anteriorly, slightly superiorly and medially. Apply the straight edge of a pencil to the lateral and superior aspect of acromion to confirm the location of the most lateral part of the border. Palpate superiorly to the top margin of the acromion border in line with the most lateral aspect and mark this most lateral aspect (Figure 4.9).



Figure 4.9 Acromiale landmark



Figure 4.10 Radiale landmark

2. Radiale

Definition: the point at the proximal and lateral border of the head of the radius (Figure 4.10).

Location: palpate downward into the lateral dimple of the right elbow. It should be possible to feel the space between the capitulum of the humerus and the head of the radius. Move the thumb distally onto the most lateral part of the proximal radial head and make a small indentation on the skin at this point with the thumbnail for accurate marking. Correct location can be checked by slight rotation of the forearm which causes the head of the radius to rotate.

3. Acromiale-radiale

Definition: the linear distance between the acromiale and radiale sites.

Location: the participant assumes a relaxed standing position with the arms hanging by the sides and right forearm pronated. Using a large sliding caliper or segmometer instead of a tape will allow for clearance of the deltoids. One branch of the caliper or segmometer is anchored on the acromiale while the other branch is placed on the radiale. This represents the upper arm length. You need this length to identify the mid-acromiale-radiale landmark (Figure 4.11).



Figure 4.11 Mid-acromiale-radiale landmark

4. Mid-acromiale-radiale

Definition: the mid-point of the straight line joining the acromiale and the radiale.

Location: measure the linear distance between the acromiale and radiale with the arm relaxed and extended by the side. Measure this distance using a segmometer or large sliding caliper as it is not acceptable to follow the curvature of the arm. Bring the lower edge of the segmometer or large sliding caliper up to the level of the mid-point between these two landmarks and make a small indentation on the skin with the instrument. Place a small horizontal mark at this point.

5. Triceps skinfold site

Definition: the point on the posterior surface of the arm in the mid-prone position, in the mid-line, at the level of the marked mid-acromiale-radiale landmark.

Location: using a tape measure, project the mid-acromiale-radiale site perpendicularly to the long axis of the arm around the back of the arm (Figure 4.12). Intersect the projected line with a vertical line in the middle of the arm when viewed from behind (Figure 4.13). It may be necessary to slightly abduct the arm to find the mid-line of the arm.



Figure 4.12 Technique to project the mid-acromiale-radiale landmark to the triceps and biceps skinfold site



Figure 4.13 Triceps skinfold site

6. Biceps skinfold site

Definition: the point on the anterior surface of the arm, in the mid-prone position, at the level of the mid-acromiale-radiale landmark, in the middle of the muscle belly (Figure 4.14).



Figure 4.14 Biceps skinfold site

Location: similar to the triceps skinfold site, using a tape measure, project the mid-acromiale-radiale site perpendicularly to the long axis of the arm around to the front of the arm, and intersect the projected line with a vertical line in the middle of the muscle belly when viewed from the front. It may be necessary to slightly abduct the arm to find the middle of the muscle belly. NB: this may be medial from the mid-line of the anterior surface of the arm.

7. Subscapular

Definition: the under most tip of the inferior angle of the scapula.

Location: ensure the participant maintains a relaxed standing position as the skin at this site is quite pliable and prone to error with participant movement. Palpate the inferior angle of the scapula with the left thumb starting medially and running the thumb under the under most tip of the scapula. If there is extreme difficulty locating the inferior angle of the scapula, the participant should slowly reach behind the back with the right arm. The inferior angle of the scapula should be felt continuously as the hand is again placed by the side of the body. A final check of this landmark should be made ensuring the arm is released completely back to the relaxed position. Always release the site and re-check this mark.

8. Subscapular skinfold site

Definition: the site 2 cm along a line running laterally and obliquely downward from the subscapular landmark at a 45° angle.

Location: use a tape measure to locate the point 2 cm from the subscapular in a line 45° laterally downward (Figure 4.15). You may need to ask female participants to reach behind their back with their left arm to move their bra out of the way.

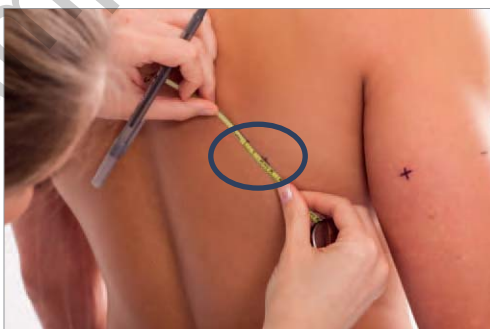


Figure 4.15 Subscapular skinfold site

9. Iliocristale

Definition: the point on the iliac crest where a line drawn from the mid-axilla (middle of the armpit), on the longitudinal axis of the body, meets the ilium.

Location: ask the participant to put their right hand on their left shoulder. Use your left hand to stabilise the body by providing resistance on the left side of the pelvis. Find the general location of the top of the iliac crest with the right hand by rolling the heel of the thumb or using the palms of the fingers. Once the general position has been located, find the specific edge of the crest by horizontal palpation with the tips of the fingers. Once identified, draw a horizontal line at the level of the iliac crest (Figure 4.16). Draw an imaginary line from the mid-axilla down the mid-line of the body. The landmark is at the intersection of the two lines.



Figure 4.16 Iliocristale and iliac crest skinfold site

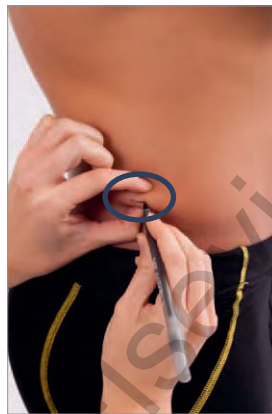


Figure 4.17 Technique to locate iliac crest skinfold site

10. Iliac crest skinfold site

Definition: the site at the centre of the skinfold raised immediately above the marked iliocristale.

Location: ask the participant to put their right hand on their left shoulder. This skinfold is raised superior to the iliocristale. To do this, place the left thumb tip on the marked iliocristale site, and raise the skinfold between the thumb and index finger of the left hand (Figure 4.17). The fold runs slightly downwards anteriorly as determined by the natural fold of the skin. Once the skinfold has been raised, mark its centre with a cross (+) (Figure 4.16).

11. Iliospinale

Definition: the most inferior or under most part of the tip of the anterior superior iliac spine (Figure 4.18).

Location: as this landmark is usually below the level of the waistband, it may be appropriate to ask the participant to assist with the identification of this site and by lowering their pant-line on the right side. Palpate the superior aspect of the ilium and follow anteriorly and inferiorly along the crest until the prominence of the ilium runs posteriorly. The landmark is marked at the lower margin or edge where the bone can just be felt. Difficulty in appraising the landmark can be assisted by the participant lifting the heel of the right foot and rotating the femur outward. Because the sartorius muscle originates at the site of the iliospinale, this movement of the femur enables palpation of the muscle and tracing to its origin. Note: on females, the landmark is usually proportionally lower on the trunk, due to the flatter and broader shape of the female pelvis.

12. Supraspinale skinfold site

Definition: the point at the intersection of two lines: (1) the vertical line from the marked iliospinale to the anterior axillary border; and (2) the horizontal line at the level of the marked iliocristale.

Location: using a tape measure, locate the line that runs from the anterior axillary border (i.e. the front of the armpit) to the iliospinale and draw a short line along the side roughly at the level of the iliocristale (Figure 4.18). It may be useful to ask the participant to hold the tape at the anterior axillary border with their left hand. Then run the tape horizontally around from the marked iliocristale to intersect the vertical line (Figure 4.19).



Figure 4.18 Part 1: technique used for the location of the supraspinale skinfold site



Figure 4.19 Part 2: technique used for the horizontal intersection for the supraspinale skinfold site

13. Abdominal skinfold site

Definition: the point 5 cm horizontally to the right-hand side of the omphalion (mid-point of the navel) (Figure 4.20).



Figure 4.20 Abdominal skinfold site

Location: using a tape measure, this site is measured horizontally across 5 cm to the right from the mid-point of the navel. Note: the distance of 5 cm assumes an adult height of approximately 170 cm. Where height differs markedly from this, the distance should be scaled for height. For example, if the stature is 120 cm, the distance will be $5 \times 120/170 = 3.5$ cm.

14. Front thigh skinfold site

Definition: the mid-point of the linear distance between the inguinal point (the point at the intersection of the inguinal fold and the mid-line of the anterior thigh) and the patellare (the mid-point of the posterior superior border of the patella).

Location: the participant assumes a seated position with the torso erect and the arms hanging by the sides. The knee of the right leg should be bent at a right angle. The measurer stands facing the right side of the seated participant on the lateral side of the thigh. If there is difficulty locating the inguinal

fold (the crease at the angle of the trunk and the anterior thigh) the participant should flex the hip to make a fold. Using a segmometer or large sliding caliper, measure from the inguinal fold to the posterior superior border of the patella (Figure 4.21). Mark the point that is equidistant between these two landmarks in the mid-line of the thigh (Figure 4.22).



Figure 4.21 Technique used to locate front thigh skinfold site



Figure 4.22 Front thigh skinfold site

15. Medial calf skinfold site

Definition: the point on the most medial aspect of the calf at the level of the maximal girth.

Location: ask the participant to stand on top of an anthropometric box with their feet separated and their body mass evenly distributed. Using a tape measure, find the maximum circumference of the calf. Begin measuring girths proximally and using the middle fingers to manipulate the position of the tape in a series of distal and proximal movements (Figure 4.23). Once the maximal level is located, the point is marked on the medial aspect of the calf with a small cross (+).



Figure 4.23 Technique used to locate medial calf skinfold site



Figure 4.24 Technique used to ensure fingers pinch exactly on the located skinfold site

PROTOCOL

Skinfolds

- 1 Prior to the measurement of skinfolds, verify the skinfold caliper is accurately measuring the distance between the centre of its contact faces with the use of vernier calipers.
- 2 The fold is picked up with the near edge of the thumb and finger in line with the marked site, and the back of the hand facing the measurer (Figure 4.24). The fold should be grasped and lifted so that a parallel, double-fold of skin (including the underlying subcutaneous adipose tissue) is held between the thumb and index finger of the left hand. Note: avoid grasping large folds creating a 'mushroom' effect or small folds where the caliper may slip off and cause pain and discomfort..

- 3 The nearest edge of the caliper is applied 1 cm away from the edge of the thumb and finger. The centre of the caliper faces should be placed at a depth of approximately mid-fingernail.
- 4 The caliper is held at 90° to the surface of the skinfold in the three spacial planes all times. Ensure the fold is held while the caliper is in contact with the skin.
- 5 Measurement is taken 2 seconds after full pressure of the caliper is applied. Note: the caliper handles should be released during measurement.
- 6 Skinfold sites are measured in succession (i.e. one set of each skinfold measure is taken before returning to each site for the duplicate measure, reducing the effects of skinfold compressibility and technician bias).
- 7 Skinfold measurements are taken in duplicate. A third measurement should be taken where the second measurement is $>7.5\%$ of the first for skinfolds.

1. Triceps

Definition: the skinfold measurement taken parallel to the long axis of the arm at the triceps skinfold site.

Location: the right arm of the participant should be relaxed with the shoulder joint slightly externally rotated to the mid-prone position and elbow extended by the side of the body. The skinfold is raised with the left thumb and index finger on the marked posterior mid-acromiale-radiale line. The fold is vertical and parallel to the line of the upper arm. Ask the participant to extend, then relax, and then take the skinfold measurement (Figure 4.25).



Figure 4.25 Triceps skinfold



Figure 4.26 Subscapular skinfold



Figure 4.27 Biceps skinfold

2. Subscapular

Definition: the skinfold measurement taken with the fold running obliquely downwards at the subscapular skinfold site.

Location: the skinfold is taken at the subscapular skinfold site which is marked 2 cm laterally and obliquely downward from the subscapular landmark at a 45 degree angle as determined by the natural fold lines of the skin (Figure 4.26). You may need to ask female participants to reach behind their back with their left arm to move their bra out of the way.

3. Biceps

Definition: the skinfold measurement taken parallel to the long axis of the arm at the biceps skinfold site (Figure 4.27).

Location: the right arm of the participant should be relaxed with the shoulder joint slightly externally rotated to the mid-prone position and elbow extended by the side of the body. The skinfold is raised

with the left thumb and index finger on the marked anterior mid-acromiale-radiale line. The fold is vertical and parallel to the line of the upper arm. Take the skinfold while the arm is relaxed. As the bicep skinfold is generally a small skinfold, take care not to pinch too deep causing a triple fold of the skin.

4. Iliac crest

Definition: the skinfold measurement taken near horizontal at the iliac crest skinfold site.

Location: the right arm of the participant should be either abducted or placed across the trunk. This skinfold is raised immediately superior to the iliocrestale on the mid-axilla line. This fold runs slightly downward posterior-anterior, as determined by the natural fold lines of the skin (Figure 4.28). This skinfold is equivalent to that described by Durnin and Wormersley[24] as the suprailiac skinfold.



Figure 4.28 Iliac crest skinfold



Figure 4.29 Supraspinale skinfold

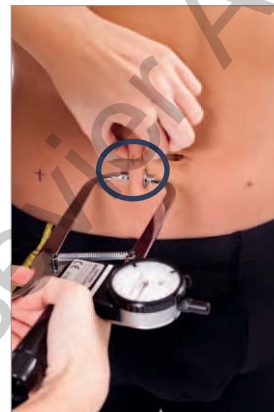


Figure 4.30 Abdominal skinfold

5. Supraspinale

Definition: the skinfold measurement taken with the fold running obliquely and medially downward at the supraspinale skinfold site.

Location: the participant assumes a relaxed standing position with the arms hanging by the sides. The fold runs medially downward and anteriorly at about a 45° angle as determined by the natural fold lines of the skin (Figure 4.29).

6. Abdominal

Definition: the skinfold measurement taken vertically at the abdominal skinfold site.

Location: the participant assumes a relaxed standing position with the arms hanging by the sides. This is a vertical fold raised 5 cm from the right-hand side of the mid-point of the navel (Figure 4.30). Make sure the initial grasp is firm and broad since often the underlying musculature is poorly developed. This may result in an underestimation of the thickness of the subcutaneous layer of tissue. Do not place the fingers inside the navel. If the skinfold is thick enough for this to occur, move the mark over to the right so the fingers are placed beside the navel. Record the distance from the mid-point of the fold to the mid-point of the navel for re-test measures.

Note: according to ISAK guidelines for the abdominal skinfold site, if your participant is 'significantly' taller or shorter than 170 cm, then you should be adjusting the standard 5 cm distance to the right of the navel (i.e. for a 140 cm participant: $140 \text{ cm} / 170 \text{ cm} \times 5 \text{ cm} = 4.1 \text{ cm}$).

7. Front thigh

Definition: the skinfold measurement taken parallel to the long axis of the thigh at the front thigh skinfold site.

Location: the participant assumes a seated position at the front edge of the anthropometric box with the torso erect, the arms supporting the hamstrings and the leg extended. The measurer stands facing the right side of the participant on the lateral side of the thigh. Note that the site is marked while the knee is bent, however, the skinfold measurement is taken with the leg extended. The participant can assist by raising the underside of the thigh to relieve the tension of the skin. If the participant has particularly tight skinfolds, the recorder can assist by standing on the left and raising the fold with both hands, at about 6 cm either side of the landmark (Figure 4.31). The measurer then raises the skinfold at the marked site and takes the measurement.



Figure 4.31 Front thigh skinfold

8. Medial calf

Definition: the skinfold measurement taken vertically at the medial calf skinfold site.

Location: the participant assumes a relaxed standing position with the right foot placed on the box and calf relaxed. The right knee is bent at 90°. Note that the site is marked with the participant standing on the anthropometric box, however, the skinfold measurement is taken with the right foot placed on the box. The vertical fold is raised on the medial aspect of the calf at a level where it has maximal circumference. The fold is parallel to the long axis of the leg (Figure 4.32).



Figure 4.32 Medial calf skinfold

DATA ANALYSIS

- 1 After landmarking your participant, measure the specified skinfolds and girths in duplicate or triplicate as required.
- 2 Estimate body density using the following regression equations and record values.

FEMALES**Withers et al.[25] — six site formula**

$$\text{Body density} = 1.20953 - [0.08294 \times (\log_{10} X_1)]$$

Where X_1 = sum of six skinfolds (in mm): triceps, subscapular, supraspinale, abdominal, front thigh, medial calf.

Participant population: cross-section of body types and levels of habitual activity.

Jackson and Pollack[26] — three site formula

$$\text{Body density} = 1.099421 - [0.0009929 \times (X_1)] + [0.0000023 \times (X_1)^2] - [0.0001392 \times (\text{age})]$$

Where X_1 = sum of three skinfolds (in mm): triceps, iliac crest, front thigh.

Participant population: cross-section of body types and levels of habitual activity.

Jackson, Pollack and Ward[27] — four site formula

$$\text{Body density} = 1.096095 - 0.0006952 (X_1) + 0.0000011 (X_1)^2 - 0.0000714 (\text{age})$$

Where X_1 = sum of four skinfolds (in mm): triceps, iliac crest, abdomen, front thigh.

Participant population: females 18–29 years across all sporting activities.

MALES**Withers et al.[25] — seven site formula**

$$\text{Body density} = 1.0988 - [0.0004 \times (X_1)]$$

Where X_1 = sum of seven skinfolds (in mm): triceps, subscapular, biceps, supraspinale, abdominal, front thigh, medial calf.

Participant population: state representative athletes from numerous different sports.

Durnin and Womersley[24] — four site formula

$$\text{Body density} = 1.1765 - [0.0744 (\log_{10} X_1)]$$

Where X_1 = sum of four skinfolds (in mm): triceps, biceps, subscapular, iliac crest.

Participant population: participants deliberately selected to represent a variety of body types.

Katch and McArdle[28] — three site formula

$$\text{Body density} = 1.09665 - (0.00103 \times X_1) - (0.00056 \times X_2) - (0.00054 \times X_3)$$

Where X_1 = triceps (in mm), X_2 = subscapular (in mm), X_3 = abdominal (in mm).

Participant population: college physical education students.

3 Estimate body fat using the following equation and record values**Siri[29] equation**

$$\% \text{ body fat} = [(4.95 / \text{Body density}) - 4.50] \times 100$$

Data recording				
Participant: _____		Date: _____		Age: _____ (y) Sex: M / F
Measure	Trial 1	Trial 2	Trial 3 (If required) ⁱ	Mean or median ^j
SKINFOLDS (mm)				
Triceps				
Subscapular				
Biceps				
Iliac crest				
Supraspinale				
Abdominal				
Front thigh				
Medial calf				
Sum of 6 skinfolds percentile (according to Table 4.6): _____				
Female body density and body fat percentage				
Equation	Body density		Body fat (%)	
Withers et al.[25]				
Jackson and Pollack[26]				
Jackson, Pollack and Ward[27]				
Male body density and body fat percentage				
Equation	Body density		Body fat (%)	
Withers et al.[25]				
Durnin and Womersley[24]				
Katch and McArdle[28]				

INTERPRETATION, FEEDBACK AND DISCUSSION

Consider the four steps of interpretation located in the 'interpretation, feedback and discussion' section at the start of this manual and refer to Table 4.6.

Issues to consider:

- How much did body fat differ depending on the equation used? Consider the possible reasons for these discrepancies in body fat percentage.
- Do the results appear to be an accurate representation of body fat, taking into consideration training status, body mass, BMI and WHR?

ⁱTake a third measure if the difference between trials 1 and 2 differs by >7.5%.

^jRecord the mean if only two measures are taken. Record the median if three measures are taken.

Table 4.6 Sum of six skinfolds* — Australian population normative data

PERCENTILES	AGE (years)					
	18–29	30–39	40–49	50–59	60–69	70–78
	MALES					
5	30.3	31.7	49.1	42.8	46.5	34.3
25	41.5	64.1	69.1	68.7	66.4	53.5
50	62.8	80.6	88.5	88.5	80.6	73.5
75	89.6	102.9	106.9	106.4	101.9	87.2
95	140.2	146.6	156.1	138.7	144.6	109.0
Mean	71.7	84.4	92.2	89.3	86.4	72.0
Standard deviation	37.8	32.0	32.2	28.8	27.9	20.9
Participants	92	120	137	110	108	32
	FEMALES					
5	51.6	49.5	66.1	60.7	67.1	65.8
25	79.1	74.7	91.1	105.9	106.5	98.4
50	103.2	100.3	129.8	141.5	134.7	129.1
75	141.9	140.7	168.2	174.1	160.3	149.2
95	204.2	201.4	222.3	211.0	201.4	193.4
Mean	112.5	110.1	133.3	139.7	134.6	127.8
Standard deviation	45.7	45.7	48.0	43.8	38.6	34.7
Participants	85	130	139	125	87	26

*The skinfolds assessed were biceps, triceps, subscapular, mid-abdominal, supraspinale and medial calf measured in mm.
Source: Gore & Edwards[30]

As demonstrated, estimates of body density, fat mass (FM) and/or fat-free mass (FFM) are derived from skinfold data using one of many available equations. Because these equations are population specific, only equations derived from individuals with similarities in age, sex, body composition and activity levels should be considered for use. Consequently, amongst athletes, skinfold equations derived from athletic populations such as that of Withers et al.[25] are likely to offer a more accurate estimate of body composition.[31] Furthermore, compatibility in technical aspects of data collection, including anatomical landmarking and high quality anthropometric equipment is also essential.

Despite the advancement in physique assessment techniques, and the notable desire of participants wishing to know their 'body fat percentage', practitioners are advised to use raw anthropometric data [e.g. sum of six skinfold = 54 mm] rather than attempt to make estimates of whole-body composition from available equations[32] (Table 4.7).

Amongst obese populations achieving only modest weight loss, visceral adipose tissue may decrease preferentially over subcutaneous fat mass, although this effect is attenuated with greater weight loss.[17] Given this, consideration should be given to routine measures of visceral fat mass, including field based options such as girth measures.

Table 4.7 Interpretation of changes in physique traits based on skinfold and body mass data

ANTHROPOMETRIC TRAIT		INTERPRETATION — PHYSIQUE TRAIT	
Body mass	Skinfolds	Muscle mass	Body fat
Increase	Stable	Gain	No change
Decrease	Stable	Loss	No change
Stable	Increase	Loss	Gain
Stable	Decrease	Gain	Loss
Increase	Increase	Potential gain	Gain
Increase	Decrease	Gain	Loss
Decrease	Increase	Loss	Gain
Decrease	Decrease	Potential loss	Loss

Activity 5 Bio-electrical impedance analysis

AIM: to assess total body water, fat mass (FM) and fat-free mass (FFM) using a bio-electrical impedance (BIA) device, interpret the results and provide feedback to a participant.

BACKGROUND

BIA has become increasingly popular as a tool for assessing the physique traits of individuals given its relative ease of use, portability and cost effectiveness. It is a safe and non-invasive method to assess physique traits that is based on the differing electrical conductivity of FM and FFM.[33,34] FFM contains water and electrolytes and is a good electrical conductor, while anhydrous fat mass is not. The method involves measuring the resistance (R) to flow of a low level current/s.[35] Resistance is proportional to the length (L) of the conductor (in this case the human body) and inversely proportional to its cross sectional area. A relationship then exists between the impedance quotient (i.e. L^2/R) and the volume of water (total body water) which contains electrolytes that conduct the electrical current. In practice, height in centimetres is substituted for length. Therefore, a relationship exists between FFM (approximately 73% water) and height (cm) $^2/R$. FM is obtained from FFM by subtracting the value for FFM from total body mass.[33]

Although the relationship between FFM and impedance is readily accepted, there are several assumptions associated with the use of BIA to measure body composition. Firstly, the human body is assumed to be a cylinder with a uniform length and cross sectional area. Rather, the human body more closely resembles several cylinders. The body parts with the smallest FFM (the limbs) have the greatest influence on whole-body resistance. The trunk, which is a shorter, thicker segment, contains ~50% of body mass, but contributes a minor amount to the overall resistance. Second, it is assumed the conducting material within the cylinder is homogeneous. Finally, the resistance to current flow per unit length of a specific conductor is assumed to be constant. However, this will vary depending on tissue structure, hydration status and electrolyte concentration of the tissue.[36]

Due to the relevance of body water to conductivity of electrical current, there is substantial evidence that BIA is not valid for assessment of individuals with abnormal hydration such as visible oedema, ascites, kidney, liver and cardiac disease and pregnancy.[37] Exercise-induced hypohydration to a level of 3% body mass has been shown to decrease the estimate of FM via BIA by 1.7%. Conversely, acute rehydration increased estimates of FM by 3.2%, with a further increase in the estimate of FM as a

state of hyperhydration was achieved.[38] Even the ingestion of relatively small volumes of fluid (591 mL) has been shown to increase estimates of FM.[37] Consequently, participants should remain fasted and euhydrated for at least 8 hours prior to assessment.[37] Given this, it would be prudent to undertake assessments in the morning prior to breakfast wherever possible, with participants encouraged to present in a well-hydrated state; assessment of which could be done via the collection of a first-morning urine sample.

PROTOCOL SUMMARY

Have the participant lie in a supine position, locate the anatomical landmarks on the right hand/wrist and foot/ankle before attaching the BIA electrodes to determine total body water, FM and FFM.

PRE-TEST INSTRUCTIONS: the participant should present in a well-hydrated state (can be confirmed using an array of parameters, including urinary indices) and ideally after an overnight fast with no physical activity for the last 8 hours. The bladder should be evacuated prior to assessment and all metal objects removed. The facility for assessment should offer privacy for the participant and be maintained to ensure thermoneutral conditions.

PROTOCOL

- 1 Follow the pre-test requirements described in Appendix A.
- 2 Undertake calibration procedures in accordance with manufacturers guidelines.
- 3 Weigh the participant on a calibrated scale in minimal clothing.
- 4 Measure stretch stature using a wall mounted stadiometer.
- 5 Request relevant demographic data from the participant, including ethnicity, age, sex, etc., ensuring the most valid equations can be used in subsequent analysis.
- 6 Place the participant in a supine position on a flat even surface free of any metal. The limbs should be abducted; arms at 30° from the trunk and legs separated at 45°. This position should be maintained for at least 10 minutes prior to assessment to minimise the influence of body water shifts between compartments.
- 7 Clean all electrode sites with alcohol swabs prior to electrode placement and allow to dry.
- 8 Place two electrodes on the right hand/wrist: one on the dorsal surface of the hand 1 cm proximal to the third metacarpophalangeal joint and the other centrally on the dorsal side of the wrist in line with the ulnar head (Figure 4.33).



Figure 4.33 Bioelectrical impedance analysis

- 9 Place two electrodes on the right foot/ankle: one on the dorsal surface of the foot 1 cm proximal to the second metatarsophalangeal joint, and the other centrally on the dorsal surface of the ankle between the lateral and medial malleoli.
- 10 Ensure all electrodes are placed at least 5 cm apart.
- 11 Initiate data collection and record results as displayed on the monitor.

Data recording

Participant: _____ Date: _____ Age: _____ (y) Sex: M / F

Record the data presented on the BIA device.

Fat-free mass: _____ kg _____ %

Fat mass: _____ kg _____ %

Total body water: _____ L _____ %

Intracellular water: _____ L _____ %

Extracellular water: _____ L _____ %

Calculate % body fat by dividing fat mass by body mass

% body fat: _____ %

Fat mass percentile (according to Table 4.8)

Percent body fat percentile (according to Table 4.8)

INTERPRETATION, FEEDBACK AND DISCUSSION

Consider the four steps of interpretation located in the 'interpretation, feedback and discussion' section at the start of this manual and refer to Table 4.8.

Table 4.8 Australian population fat mass and % body fat normative data

PERCENTILES	FAT MASS (kg)		BODY FAT (%)	
	MALES	FEMALES	MALES	FEMALES
0	1.9	4.4	2.4	8.1
20	17.4	20.1	24.0	34.1
40	21.3	24.4	27.5	38.4
50	23.0	26.5	29.0	40.2
60	24.9	28.8	30.4	41.9
80	29.4	35.0	33.6	45.8
100	79.1	94.2	52.5	63.0

Based on data from 16 969 men and 24 344 women aged 27–75 years enrolled in the Melbourne Collaborative Cohort Study from 1990–1994. Data were collected using a single frequency (50 Hz) BIA-101A RJL system analyser (RJL Systems, Detroit, Michigan). Data are median baseline values. Very poor <20th percentile, Poor = 21st–40th percentile, Average = 41st–60th percentile, Good = 61st–80th percentile, Excellent >81st percentile.

Source: Simpson et al.[38]

Issues to consider:

- How much did body fat differ from the percentage body fat calculated from the skinfold measures? Consider the possible reasons for these discrepancies in body fat percentage.
- Do the results appear to be an accurate representation of body fat, taking into consideration training status, body mass, BMI and WHR?

Due consideration of the limitations and assumptions of each mode of body fat calculation (i.e. skinfold equations and BIA) and the extraneous factors influencing each measure (e.g. hydration status, activity level) are essential when determining which body fat measurement is most accurate for your participant according to their current situation.

Worked case studies

SETTING

You are a sport scientist working at an elite sports institute, providing scientific services to the [swimming] program. One of your roles includes the monitoring of body composition of male and female swimmers in the squad on a routine basis. Assessments are always undertaken prior to the morning training session, and include measurements of body mass, height and sum of seven skinfolds.

CASE STUDY 1

You have a 19-year-old female athlete taken measurements from, and you are now required to provide feedback on these results in relation to the previous measurements 8 weeks ago. The previous measurement was made during the competition season, and the athlete has currently been in the off-season for the previous 6 weeks. The results from both sessions are below.

28th February	Height = 170.0 cm	Mass = 72.4 kg	Sum of 7 Skinfolds = 104 mm
2nd May	Height = 169.8 cm	Mass = 76.6 kg	Sum of 7 Skinfolds = 136 mm
Difference:	Height = -0.2 cm	Mass = +4.2 kg	Sum of 7 Skinfolds = +32 mm

What are the considerations when interpreting and providing feedback to the athlete?

What are the factors you need to consider to determine whether this is a real change?

To determine whether this is a real change, you consider the impact of the:

- 1 equipment: the equipment has been kept consistent and verified prior to each session, therefore you expect minimal influence of the equipment on the result
- 2 tester: you are a level 3 ISAK accredited anthropometrist and are confident that your intra-individual variability is small enough to detect this change
- 3 time and preparation: the time of day and participant preparation, including attending in a fasted state and well-hydrated prior to testing, has been kept the same for both measures
- 4 time between sessions: the time between testing sessions is sufficient to see real change.

Therefore, as the aforementioned considerations appear to be well controlled between testing sessions and the increase in body mass of 4.2 kg is consistent with the increase of 32 mm in skinfold thickness, it is likely that a real change has occurred since the previous assessment. According to Table 4.7, an increase in both body mass and skinfold thickness indicates a potential gain in muscle mass and a gain in fat mass.

Is this likely to impact on this athlete's swimming performance? If so, what suggestions would you make?

You do some research and find out that the results are higher than the 'normal' range for female swimmers (approximately 50–80 mm).^[39] In consultation with her coach, you suggest to the participant that she may consider modifying her body composition with a goal to lower body fat levels into the normal range over a sufficient timeframe.

What other issues should be addressed with this type of athlete when providing feedback?

When providing this type of feedback, it is important to gain an understanding of the participant's thoughts, feelings and concerns and then respond to these empathetically. The words you choose to convey the results to the participant should be well thought through, taking into consideration

Worked case studies (continued)

the mental health of the young female swimmer. Although the athlete is 19 years old, it may be beneficial to ensure that a parent, coach or other sport scientist is in the room at the time the feedback is provided to minimise the risk that this message is interpreted in a negative manner. The focus of the feedback should be on the ability to make small changes to the athlete's body fat levels in order to optimise performance.

SETTING

You work in a health and fitness centre. Members may undertake a number of anthropometry measures as part of their initial health assessment. The results of these measures are used to prescribe an appropriate exercise program for the individual. You are responsible for conducting the health assessment and are expected to give feedback to the participant during the appointment on their results and also how those results will influence your choices as to which exercises will be prescribed for them.

CASE STUDY 2

The participant is a 38-year-old male who is currently training for his first weight lifting competition. In addition to 2 aerobic training sessions, he has been performing resistance training 4 days a week for the previous 4 months. He was sent an email by one of his friends telling him how to calculate BMI. He calculated his own BMI as 27 kg/m^2 and saw that this classified him as 'overweight' and at an increased risk of diseases such as diabetes, hypertension and cardiovascular disease. He asks for you to test him 'to check if this is right'.

Consider what test/s you would perform on this participant and why.

You decide to take this man through basic measures of height and body mass to confirm his calculations. You also decide to add measures of waist circumference and BIA as the centre has a BIA device and you are not confident on your skinfold technique. The participant has the following results.

Height and body mass data recording sheet

Measure	Trial 1	Trial 2	Trial 3 (if required)	Mean or median
Height (cm)	178.2	178.0	—	174.1
Body mass (kg)	82.2	82.2	—	82.2
BMI = 27.1 kg/m^2				
Classification (according to Table 4.1): overweight.				
Risk of obesity-related diseases from BMI and waist circumference (according to Table 4.1): no increased risk.				
Measure	Trial 1	Trial 2	Trial 3 (if required)	Mean or median
GIRTHS				
Waist (cm)	82.2	75.2	81.8	81.8

continued overpage

Worked case studies *(continued)*

Waist circumference risk stratification: 27.1 _____

Waist-to-height ratio risk stratification: Not at increased risk

BIA:

Fat mass: 19.3 kg

% body fat: 23.9 %

Fat mass percentile (according to Table 4.8): 30th percentile

Percent body fat percentile (according to Table 4.8): 20th percentile

Interpretation: the participant's BMI is 27.1 kg/m² which classifies him as 'overweight' according to Table 4.1. His waist circumference places him at the low risk of obesity-related diseases according to Table 4.3. His waist-to-height ratio or ICO does not place him at increased health risk. His results from BIA placed him in the 30th percentile for fat mass and in the 20th percentile for % body fat.

Discussion and feedback: you would first provide his values and clarify that he is correct that his BMI does place him in the overweight category. However, it is important that you then clarify that this test was developed to classify obesity-related disease risk within populations and when BMI cut-offs are applied at an individual level, a number of assumptions are made that may result in inappropriate classification of disease risk. You explain that BMI is unable to distinguish between the composition of total body mass, thus more muscular individuals are often categorised at an increased disease risk due to their higher body mass relative to their height. As such, BMI is best combined with a measure of body fat distribution such as a waist girth, WHR or ICO, as this more accurately describes disease risk.

In line with this, you explain that the waist circumference indicates he is at a low risk of obesity-related diseases and this is supported by the ICO and BIA measures of fat mass and % body fat. Due to his smaller waist circumference, his higher BMI does not classify him at increased risk of obesity-related diseases either. This result appears in line with his current training and goals. Ask the participant if he has any questions about the tests or his results.

REFERENCES

- [1] National Health and Medical Research Council. Clinical Practice Guidelines for the Management of Overweight and Obesity in Adults. Canberra: Author; 2003.
- [2] Reilly T, Tyrrell A, Troup JD. Circadian variation in human stature. *Chronobiol Int* 1984;1(2):121–6.
- [3] Sumner EE, Whitacre J. Some factors affecting accuracy in the collection of data on the growth of weight in school children. *J Nutr* 1931;4:15–33.
- [4] Maughan R, Shirreffs S. Exercise in the heat: challenges and opportunities. *J Sports Sci* 2004;22(10):917–27.
- [5] Stein RJ, Haddock CK, Poston WS, et al. Precision in weighing: a comparison of scales found in physician offices, fitness centers, and weight loss centers. *Public Health Rep* 2005;120(3):266–70.
- [6] Bunt JC, Lohman TG, Boileau RA. Impact of total body water fluctuations on estimation of body fat from body density. *Med Sci Sports Exerc* 1989;21(1):96–100.
- [7] Reis JP, Macera CA, Araneta MR, et al. Comparison of overall obesity and body fat distribution in predicting risk of mortality. *Ob* 2009;17(6):1232–9. [Epub 2009 Feb 5].
- [8] Janssen I, Mark AE. Elevated body mass index and mortality risk in the elderly. *Obes Rev* 2007;8(1):41–59.
- [9] Kvamme JM, et al. Body mass index and mortality in elderly men and women: the Tromsø and HUNT studies. *J Epidemiol Community Health* 2011;14:14.
- [10] Rush EC, Freitas I, Plank LD. Body size, body composition and fat distribution: comparative analysis of European, Maori, Pacific Island and Asian Indian adults. *Br J Nutr* 2009;102(4):632–41.
- [11] Stevens J, Nowicki EM. Body mass index and mortality in asian populations: implications for obesity cut-points. *Nutr Rev* 2003;61(3):104–7.

- [12] Taylor RW, Brooking L, Williams SM, et al. Body mass index and waist circumference cutoffs to define obesity in indigenous New Zealanders. *Am J Clin Nutr* 2010;92(2):390–7.
- [13] Bray GA. Don't throw the baby out with the bath water. *Am J Clin Nutr* 2004;79(3):347–9.
- [14] Folsom AR, Kaye SA, Sellers TA, et al. Body fat distribution and 5-year risk of death in older women. *JAMA* 1993;269(4):483–7.
- [15] Heyward VH, Stolarczyk LM, editors. *Applied Boyd Composition Assessment*. Champaign (IL): Human Kinetics; 1996. p. 12.
- [16] Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. *Int J Food Sci Nutr* 2005;56(5):303–7.
- [17] Stewart A, Marfell-Jones M, Olds T, et al. *International Standards for Anthropometric Assessment*. Lower Hutt, New Zealand: International Society for the Advancement of Kinanthropometry (ISAK); 2011.
- [18] Norton K, Hayward S, Charles S, et al. The effects of hypohydration and hyperhydration on skinfold measurements. In: *Sixth Scientific Conference of the International Society for the Advancement of Kinanthropometry*. Adelaide: International Society for the Advancement of Kinanthropometry; 1998.
- [19] Hume P, Marfell-Jones M. The importance of accurate site location for skinfold measurement. *J Sports Sci* 2008;26(12):1333–40.
- [20] Martin AD, Ross WD, Drinkwater DT, et al. Prediction of body fat by skinfold caliper: assumptions and cadaver evidence. *Int J Obes* 1985;9(Suppl. 1):31–9.
- [21] Lohman TG. Skinfolts and body density and their relation to body fatness: a review. *Hum Biology* 1981;53(2):181–225.
- [22] Clarys JP, Provyn S, Marfell-Jones MJ. Cadaver studies and their impact on the understanding of human adiposity. *Ergonomics* 2005;48(11–14):1445–61.
- [23] Norton K, Whittingham N, Carter L, et al. Measurement techniques in anthropometry. In: Norton KI, Olds T, editors. *Anthropometrika*. Sydney: University of New South Wales Press; 1996. p. 25–76.
- [24] Durnin JV, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: Measurements on 481 men and women aged from 16 to 72 years. *Br J Nutr* 1974;32:77–97.
- [25] Withers RT, Craig NP, Bourdon PC, et al. Relative body fat and anthropometric prediction of body density of male athletes. *Eur J Appl Physiol Occup Physiol* 1987;56:191–200.
- [26] Jackson AS, Pollack ML. Practical assessment of body composition. *Phys Sports Med* 1985;13:75–90.
- [27] Jackson AS, Pollack ML, Ward A. Generalized equations for predicting body density of women. *Med Sci Sports Exerc* 1980;12(3):175–81.
- [28] Katch FI, McArdle WD. Prediction of body density from simple anthropometric measurements in college-age men and women. *Hum Biol* 1973;45:445–55.
- [29] Siri W. Body volume measurement by gas dilution. In: Brozek J, Henschel A, editors. *Techniques for measuring body composition*. Washington, DC: National Academy of Sciences, National Research Council; 1961. p. 108–17.
- [30] Gore CJ, Edwards DA. *Australian Fitness Norms: A Manual for Fitness Assessors*. Australia: The Health Development Foundation, South Australia; 1992.
- [31] Reilly T, George K, Marfell-Jones M, et al. How Well do Skinfold Equations Predict Percent Body Fat in Elite Soccer Players? *Int J Sports Med* 2009.
- [32] Johnston FE. Relationships between body composition and anthropometry. *Hum Biol* 1982;54(2):221–45.
- [33] Kyle UG, Bosaeus I, De Lorenzo AD, et al. Bioelectrical impedance analysis—part I: review of principles and methods. *Clin Nutr* 2004;23(5):1226–43.
- [34] NIH. NIH Consensus statement. Bioelectrical impedance analysis in body composition measurement. National Institutes of Health Technology Assessment Conference Statement. December 12–14, 1994. *Nutrition* 1996;12(11–12):749–62.
- [35] Withers RT, Craig NP, Bourdon PC, et al. Relative body fat and anthropometric prediction of body density of male athletes. *Eur J Appl Occup Physiol* 1987;56(2):191–200.
- [36] Saunders MJ, Blevins JE, Broeder CE. Effects of hydration changes on bioelectrical impedance in endurance trained individuals. *Med Sci Sports Exerc* 1998;30(6):885–92.
- [37] Dixon CB, Ramos L, Fitzgerald E, et al. The effect of acute fluid consumption on measures of impedance and percent body fat estimated using segmental bioelectrical impedance analysis. *Eur J Clin Nutr* 2009;63(9):1115–22.
- [38] Simpson JA, MacInnis RJ, Peeters A, et al. A comparison of adiposity measures as predictors of all-cause mortality: the Melbourne Collaborative Cohort Study. *Ob* 2007;15(4):994–1003.
- [39] Savage B, Pyne DB. Swimmers. In: Tanner RK, Gore CJ, editors. *Physiological Tests for Elite Athletes*. 2nd ed. Lower Mitcham, SA: Human Kinetics; 2013. p. 439.