

FOODS, NUTRITION AND SPORTS PERFORMANCE

An International Scientific Consensus
organized by Mars, Incorporated
with International Olympic Committee patronage

Edited by
CLYDE WILLIAMS
and
JOHN T. DEVLIN



E & FN SPON

An Imprint of Chapman & Hall

Foods, Nutrition and Sports Performance

An International Scientific Consensus
held 4–6 February 1991 and
organized by Mars, Incorporated,
with International Olympic Committee patronage

Edited by

Clyde Williams

*Department of Physical Education, Sports Science
and Recreation Management
Loughborough University
UK*

and

John T. Devlin

*University of Vermont College of Medicine
Maine
USA*



E & FN SPON

An Imprint of Chapman & Hall

London · Glasgow · New York · Tokyo · Melbourne · Madras

Published by

E & FN Spon, an imprint of Chapman & Hall, 2-6 Boundary Row, London SE1 8HN

Chapman & Hall, 2-6 Boundary Row, London SE1 8HN, UK

Blackie Academic & Professional, Wester Cleddens Road, Bishopbriggs, Glasgow G64 2NZ, UK

Chapman & Hall, 29 West 35th Street, New York NY10001, USA

Chapman & Hall Japan, Thomson Publishing Japan, Hirakawacho Nemoto Building, 6F, 1-7-11 Hirakawa-cho, Chiyoda-ku, Tokyo 102, Japan

Chapman & Hall Australia, Thomas Nelson Australia, 102 Dodds Street, South Melbourne, Victoria 3205, Australia

Chapman & Hall India, R. Seshadri, 32 Second Main Road, CIT East, Madras 600 035, India

First published as a special supplement to the *Journal of Sports Sciences*, Summer 1991

First edition 1992

© 1992 E & F N Spon

Typeset in 10/12 Times by Intype, London

Printed in Great Britain by Page Bros, Norwich

ISBN 0 419 17890 2

Apart from any fair dealing for the purposes of research or private study, or criticism or review, as permitted under the UK Copyright Designs and Patents Act, 1988, this publication may not be reproduced, stored, or transmitted, in any form or by any means, without the prior permission in writing of the publishers, or in the case of reprographic reproduction only in accordance with the terms of the licences issued by the Copyright Licensing Agency in the UK, or in accordance with the terms of licences issued by the appropriate Reproduction Rights Organization outside the UK. Enquiries concerning reproduction outside the terms stated here should be sent to the publishers at the London address printed on this page.

The publisher makes no representation, express or implied, with regard to the accuracy of the information contained in this book and cannot accept any legal responsibility or liability for any errors or omissions that may be made.

A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication data

Foods, nutrition, and sports performance: an international scientific consensus conference, held 4-6 February, 1991 / organized by Mars, Incorporated with International Olympic Committee patronage; edited by Clyde Williams and John T. Devlin.

p. cm.

Includes bibliographical references (p.) and index.

ISBN 0-419-17890-2

1. Athletes—Nutrition—Congresses. 2. Sports—Physiological aspects—Congresses. I. Williams, Clyde. II. Devlin, John T. III. Mars, Incorporated. IV. International Olympic Committee.

TX361.A8F67 1992

613.2'024796—dc20

92-13358

CIP

Foods, Nutrition and Sports Performance

Other titles from E & F N Spon

Biomechanics and Medicine in Swimming

T. Reilly, A. Lees, M. Hughes and D. MacLaren

Drugs in Sport

D.R. Mottram

Exercise

Benefits, limits and adaptations

D. MacLeod, T. Reilly, C. Williams, R. Maughan and M. Nimmo

Exercise Physiology for Health Professionals

S. Bird

Intermittent High Intensity Exercise

D. MacLeod

Leisure and Recreation Management

Third Edition

G. Torkildsen

Physiology of Sports

T. Reilly, N. Secher, P. Snell and C. Williams

Sport and Physical Activity

Moving towards excellence

L. Almond and T. Williams

Sport and Recreation

An economic analysis

C. Gratton and P. Taylor

Writing Successfully in Science

M. O'Connor

For more information about these and other titles published by us, please contact:

The Promotion Department, E & F N Spon, 2-6 Boundary Row, London SE1 8HN Telephone: 071-522-9966

Contributors

SCIENTIFIC CO-CHAIRMEN

Clyde Williams
Department of Physical Education, Sports Science and
Recreation Management
Loughborough University
Loughborough
Leicestershire
LE11 3TU

John T. Devlin
University of Vermont College of Medicine
Diabetes Center
Maine Medical Center
Portland
Maine 04102
USA

AUTHORS

Eric J. van der Beek
Department of Human Nutrition
TNO Toxicology and Nutrition Institute
P.O. Box 360
3700 AJ Zeist
The Netherlands

Per Bjorntorp
Department of Medicine I
Sahlgren's Hospital
University of Göteborg
43045 Göteborg
Sweden

F. Brouns
Nutrition Research Center
Department of Human Biology
University of Limburg
Postbus 616
6200 MD
Maastricht
The Netherlands

Priscilla M. Clarkson
Department of Exercise Science
University of Massachusetts
Amherst
MA 01003
USA

Edward F. Coyle
Human Performance Laboratory
The University of Texas at Austin
Austin
Texas 78712
USA

Mark Hargreaves
Department of Physiology
Parkville 3052
Australia

Peter W.R. Lemon
Applied Physiology Research Laboratory
Schools of Biomedical Sciences and Physical Education
Kent State University
Ohio 44242
USA

R.J. Maughan
Department of Environment and Occupational Medicine
University Medical School
University of Aberdeen
Foresterhill
Aberdeen
AB9 2ZD
Scotland

Wim H.M. Saris
Nutrition Research Center
Department of Human Biology
University of Limburg
Postbus 616
6200 MD Maastricht
The Netherlands

Klaas R. Westerterp
Nutrition Research Center
Department of Human Biology
University of Limburg
Postbus 616
6200 MD Maastricht
The Netherlands

Preface

The material in this book is the peer reviewed proceedings of the International Scientific Consensus Conference on Foods, Nutrition and Sports Performance. It first appeared as a special supplement to the *Journal of Sports Sciences* in the Summer 1991. The supplement is in huge demand and reflects the growing interest in the links between nutrition and sports performance.

Our aim in reproducing the proceedings in book form is to make it more widely available, especially to students, teachers, coaches and dietitians. One of its unique features is that the nutritional recommendations are based on the results of research studies thoroughly scrutinized by all the contributing authors and experts in sports nutrition who attended the Conference. Therefore, the implementation of the recommended nutritional strategies during the preparation for, the participation in, and the recovery from sport and exercise can be undertaken with confidence. In addition, the information and insights contained in this book provide researchers with a solid base from which they can launch new, well controlled research studies in sports nutrition.

It is our hope that the interest in this subject will continue to grow, so much so that it will be necessary to convene a second International Scientific Consensus Conference on Foods, Nutrition and Sports Performance before the end of this decade.

Clyde Williams
Loughborough University

Introduction

This Consensus Conference on *Foods, Nutrition and Sports Performance* held in Lausanne on 4–6 February 1991, and under the patronage of the Medical Commission of the International Olympic Committee, brought together leading international scientists to review the current state of knowledge regarding the role of nutrition in improving sports performance. Under the direction of the Scientific Co-chairmen, scientists, widely recognized as experts in their respective fields, presented reviews of current scientific knowledge in their areas of expertise. Seven additional research scientists and four delegates of the International Olympic Committee were also invited to participate as discussants. The list of participants represented fifteen individual countries in four continents.

All participants received, in advance, copies of the scientific manuscripts for review prior to the Consensus Conference. They were requested to prepare written comments to be discussed at the meeting. The topics covered included recommendations for optimum carbohydrate, protein, fat, total energy, fluid and electrolyte, and vitamin and mineral intakes to maximize sports performance. The topics of carbohydrate and fluid intake included a review of the general state of current knowledge in the area (descriptive), and a separate discussion of the practical application of this knowledge in the training regimen (prescriptive).

Although the primary focus of this Consensus Conference was centred on optimum food intakes for the competitive athlete, the recommendations made in the following papers may be applicable to the recreational athlete as well. This is especially true for the individuals engaged in high-intensity forms of endurance exercise, in whom the higher intakes of carbohydrates, protein and fluids may enhance physical performance and possibly decrease the risk of injury. General recommendations can be made regarding those dietary modifications shown to improve various classes of sports performance (e.g. team sports, endurance sports, body

building), but advice for the individual athlete cannot be made without specific information on the type, duration and intensity of the athletic event.

Concern was raised during the Conference about the limited data available on female athletes. Additional research is clearly needed better to define optimum training and food intake regimens to achieve desired body weight goals, and to limit the risks of reducing the body stores of calcium and iron, in particular.

For two productive days the manuscripts were individually presented, and open discussions were enjoined by all the participants. Only after the modifications recommended by the group had been incorporated into a revised manuscript was a final version approved for publication.

The Consensus Statement (p. xv) was reached after full participant discussion. A final draft of this statement was circulated prior to its presentation by the Scientific Co-chairmen at the International Olympic Committee headquarters in Lausanne on 6 February 1991. In the presence of Juan Antonio Samaranch, President of the International Olympic Committee and IOC delegates, Prince Alexandre de Merode, Chairman of the IOC Medical Commission, introduced the Consensus Statement by expressing his gratitude and support for this Conference on *Foods, Nutrition and Sports Performance*. This marks an important milestone in officially recognizing the important role of food intake in optimizing athletic performance, and reflects the positive message so urgently needed after the recent pre-occupation of the Medical Commission with illicit drug use. As stated by Prince de Merode, this Conference and its proceedings set the precedent for a new era of co-operation and mutual support between the International and National Olympic Committees and the scientific community leading to a better definition of proper nutrition for optimum sports performance.

ACKNOWLEDGEMENTS

The participants gratefully acknowledge the support of Mars, Incorporated in convening this important conference.

Foods, nutrition and sports performance: final consensus statement

Diet significantly influences athletic performance. An adequate diet, in terms of quantity and quality, before, during and after training and competition will maximize performance. In the optimum diet for most sports, carbohydrate is likely to contribute about 60–70% of total energy intake and protein about 12%, with the remainder coming from fat.

Total energy intake must be raised to meet the increased energy expended during training and maintenance of energy balance can be assessed by monitoring body weight, body composition and food intake. Where there is a need to reduce body weight this should be done gradually, and not immediately before competition.

In athletic events of high intensity and long duration (such as multiple sprint sports and endurance sports) performance is generally limited by carbohydrate availability. High carbohydrate diets (even in excess of two-thirds of total energy) maximize carbohydrate (glycogen) stores and improve performance in such activity. A high carbohydrate diet is also necessary to sustain high-intensity training on a daily basis. After each bout of exercise, the diet should contain sufficient carbohydrate to replenish the glycogen stores and to maximize subsequent performance. The requirement for sugars and starches, in both solid and liquid forms, will vary, depending on the timing and nature of the physical activity.

Increased fluid intake is necessary to avoid dehydration, and may improve performance during prolonged exercise, especially when sweat loss is high. These fluids may contain some carbohydrate, the concentration of which will be dictated by both duration of exercise and climatic conditions. If exercise is of short duration and sweat losses are small, the replacement of salts can be achieved from a normal food intake after exercise.

Protein requirements are higher in individuals involved in physical training programmes than in inactive people. However, most athletes already consume sufficient protein as a consequence of their increased energy intakes.

Fat consumption should be no greater than 30% of total energy intake. Supplementary fat beyond this intake is not recommended for training or competition because the body is able to mobilize its large reserve of this energy store. Except where there is a need to reduce body fat content, it is important to maintain these stores by ingesting sufficient energy between periods of exercise.

Vitamin supplements are not necessary for athletes eating a diet adequate in respect of quality and quantity. Of the minerals and trace elements essential for health, particular attention should be paid to iron and calcium status in those individuals who may be at risk.

There is no good evidence to support the use of other nutritional supplements, including those commonly assumed by athletes to have ergogenic effects.

Contents

Contributors	viii
Preface	xi
Introduction	xii
Foods, nutrition and sports performance: final consensus statement	xv
 1 Limits of energy turnover in relation to physical performance, achievement of energy balance on a daily basis	 1
1.1 Introduction	1
1.2 The lower limit of energy expenditure	3
1.3 The upper limit of energy expenditure	4
1.4 Changes in energy expenditure during a training programme	6
1.5 Regulation of energy balance at a changing energy turnover	9
References	11
Appendix	12
Commentary by Kiens, Rodriguez and Hamm	16
 2 Carbohydrates and exercise	 19
2.1 Introduction	19
2.2 Sources and body stores of carbohydrate	19
2.3 Carbohydrate utilization during exercise	22
2.4 Factors influencing carbohydrate utilization during exercise	25
Acknowledgement	29
References	29

3	Timing and method of increased carbohydrate intake to cope with heavy training, competition and recovery	35
3.1	Introduction	35
3.2	Carbohydrate types and metabolic rates	36
3.3	Muscle glycogen resynthesis following exercise	37
3.4	Maximizing muscle glycogen prior to competition	45
3.5	Pre-event nutrition	46
3.6	Carbohydrate feeding during exercise	51
	References	57
	Commentary by Kiens, Rodriguez and Hamm	62
	Commentary by Brouns	63
4	Effect of exercise on protein requirements	65
4.1	Introduction	65
4.2	Importance of protein	66
4.3	Factors that affect protein need	68
4.4	Summary and conclusions	79
	References	80
5	Importance of fat as a support nutrient for energy: metabolism of athletes	87
5.1	Introduction	87
5.2	Utilization of the fat depots	88
5.3	FFA fluxes in circulation during exercise	91
5.4	Adaptations by physical training	92
	References	93
6	Vitamin supplementation and physical exercise performance	95
6.1	Introduction	95
6.2	Prologue	96
6.3	Vitamin supplementation studies	98
6.4	Epilogue	106
	References	107
7	Minerals: exercise performance and supplementation in athletes	113
7.1	Introduction	113
7.2	General description of minerals	114
7.3	Determination of mineral status	114
7.4	Nutritional assessment of athletes	119
7.5	Mineral status of athletes	121
7.6	The relationship of mineral status and performance	130
7.7	Should mineral supplements be recommended?	136
7.8	Concluding remarks	137
	References	138

8	Fluid and electrolyte loss and replacement in exercise	147
8.1	Introduction	147
8.2	Availability of ingested fluids	148
8.3	Metabolic effects of carbohydrate ingestion during exercise	152
8.4	Fluid loss and temperature regulation	153
8.5	Electrolyte loss in sweat and the effects on body fluids	155
8.6	Fluid replacement during exercise	157
8.7	Effects of fluid ingestion on performance	158
8.8	Post-exercise rehydration	160
8.9	Practical issues in fluid replacement during exercise	164
8.10	Exercise intensity and duration	165
8.11	Composition of drinks	167
8.12	Environmental conditions	170
8.13	State of training and acclimation	171
	References	172
9	Heat – sweat – dehydration – rehydration: a praxis oriented approach	179
	References to Table 1	188
	Index	189

Limits of energy turnover in relation to physical performance, achievement of energy balance on a daily basis

Klaas R. Westerterp and Wim H.M. Saris

1.1 INTRODUCTION

The main component of the daily energy turnover (ADMR = average daily metabolic rate) in the average subject is the energy expenditure for maintenance processes, usually called basal metabolic rate (BMR). This is the energy expenditure for the ongoing processes in the body in the resting state, when no food is digested and no energy is needed for temperature regulation, i.e. in the post-absorptive state in a thermoneutral environment. BMR is usually expressed as a function of body size to allow comparisons between subjects and even between species. The remaining components of ADMR are the diet induced thermogenesis (DIT) and the energy expenditure for (physical) activity (EEA). DIT is a fraction of energy intake of about 10% depending on the macronutrient composition of the food consumed. EEA is the most variable component of the daily energy turnover, ranging between an average value of 25–30% up to 75% in extreme situations during heavy sustained exercise. Table 1.1 shows some examples of energy intake in endurance, strength and team sport athletes.

Food, Nutrition and Sports Performance

Edited by Clyde Williams and John T. Devlin

Published in 1992 by E & F N Spon, London. ISBN 0 419 17890 2