Preface xv List of Contributors xvii

I

NUTRITION AND HUMAN HEALTH

1. Nutritional Supplementation in Health and Sports Performance

SIDNEY J. STOHS AND EDETH K. KITCHENS

Introduction 3
Definitions 3
Nutritional Supplement Recommendations for Athletes 4
Safety Issues 6
Summary and Conclusions 6
References 6

2. Glycemic Index, Food Exchange Values and Exercise Performance

ATHANASIOS Z. JAMURTAS, CHARIKLIA K. DELI, KALLIOPI GEORGAKOULI AND IOANNIS G. FATOUROS

Glycemic Index 9
Glycemic Load 9
Glycemic Index, Glycemic Load and Metabolic
Responses 10
Glycemic Index, Metabolic Responses and Exercise
Performance 16
Glycemic Load, Metabolic Responses and Exercise
Performance 22
Food Exchange Values in Health And Exercise 24
Conclusions 24
References 25

3. Performance Enhancement Drugs and Sports Supplements for Resistance Training

LUCAS GUIMARÃES-FERREIRA, WAGNER SILVA DANTAS, IGOR MURAI, MICHAEL J. DUNCAN AND NELO EIDY ZANCHI

Introduction 29
Testosterone and Anabolic Steroids 30
Creatine Monohydrate 32
Beta-Hydroxy Beta-Methylbutyrate (HMB) 36
Caffeine 37
References 39

П

EXERCISE AND HUMAN HEALTH

4. Exercise and Cardiovascular Disease C. TISSA KAPPAGODA AND EZRA A. AMSTERDAM

Introduction 45
Physiological Responses of the Cardiovascular System to Exercise 45
Exercise and Health 48
How Much Exercise is Enough? [36] 52
Are the Benefits of Exercise Universal? 52
References 52

5. Resistance Training and Physical Exercise in Human Health

BRYAN K. SMITH AND ERIK KIRK

Resistance Training in Human Health 55 Summary 61 References 61

6. Psychology and Exercise

ATTILA SZABO, MARK D. GRIFFITHS AND ZSOLT DEMETROVICS

Acute and Chronic Psychological Effects of Exercise 65

Motivation for Exercise Behavior: Why do People Exercise? 66
Theories and Models Accounting for the Psychological Benefits of Exercise 67
The "Runners' High" Phenomenon and the Acute Psychological Effects of Exercise 68
The Dark Side of Physical Activity: Exercise Addiction 70
Conclusions 71
Acknowledgements 71
References 71

7. Bone Health, Bone Mineral Density and Sports Performance

ANNIE SCHTSCHERBYNA, BEATRIZ GONÇALVES RIBEIRO AND MARIA LUCIA FLEIUSS DE FARIAS

Introduction 75
Bone Health 75
Bone Mineral Density 77
Bone and Physical Activity 78
Conclusions 80
References 80

8. Immune Function, Nutrition, and Exercise WATARU AOI, YUJI NAITO AND TOSHIKAZU YOSHIKAWA

Introduction 83
Exercise and Upper Respiratory Tract Infection 84
Exercise and Cancer 85
Exercise and Inflammation 85
Delayed-Onset Muscle Damage 86
Nutrition and Exercise-Induced Immune Changes 87
Conclusion 89
References 90

9. The Immune Response to Exercise: Effects on Cellular Mobilization, Immune Function and Muscle Regeneration

DANIEL 1. FREIDENREICH AND IEFF S. VOLEK

The Effects of Acute Exercise on Circulating Leukocyte
Counts 95

Exercise and Immune Function 96

Muscle Damage and Leukocyte infiltration 97

Chapter Summary 99

References 99

Ш

SPORTS AND NUTRITION

10. Vegetarian Athletes
JING ZHOU, JIA LI AND WAYNE W. CAMPBELL

Nutritional Considerations for Vegetarian Athletes 105 Vegetarian Diet and Athletic Performance 109 Take-Home Messages 111 References 112

11. Nutrition in Combat Sports

GUILHERME G. ARTIOLI, EMERSON FRANCHINI, MARINA Y. SOLIS, ALINE C. TRITTO AND ANTONIO H. LANCHA JR

Introduction 115
Role of Nutrients 116
Role of Hydration 120
Rapid Weight Loss 121
Supplements for Combat Athletes 122
References 124

12. Sumo Wrestling: An Overview

TAISHI MIDORIKAWA, SHIZUO SAKAMOTO AND MASAKATSU KONDO

Introduction 129
Energy Balance 129
Fat Mass and Fat-Free Mass for Top League ("Sekitori") 130
Organ-Tissue Level Body Composition 130
Conclusion 132
References 132

13. Bioenergetics of Cyclic Sports Activities on Land: Walking, Running and Cycling

PAOLA ZAMPARO, CARLO CAPELLI AND SILVIA POGLIAGHI

Energy Expenditure of Human Locomotion 133
The Energy Cost of Locomotion 133
Energy Sources 134
Aerodynamic and Non-Aerodynamic Cost of Locomotion 134
The Determinants of C in Land Locomotion 137
Passive Locomotory Tools on Land 139
Efficiency in Land Locomotion 140
Conclusions 141
References 141

14. Bioenergetics of Cyclic Sport Activities in Water: Swimming, Rowing and Kayaking

PAOLA ZAMPARO, AND MARCO BONIFAZI

Energetics and Biomechanics of Aquatic Locomotion 143
Energetics of Swimming 145
Passive Locomotory Tools in Water 148
Rowing and Kayaking (Boat Locomotion) 148
Conclusions 149
References 149

15. Performance Enhancement Drugs and Sports Supplements: A Review of the Evidence

GARY GAFFNEY

Performance-Enhancing Drugs 151
Performance-Enhancing Supplements 155
References 158

16. Nutrition and Ultra-Endurance: An Overview

BEAT KNECHTLE

Introduction 161
Problems Associated with Ultra-Endurance Performance 161
Nutritional Aspects in Ultra-Endurance Athletes 165
Conclusions and Implications for Future Research 167
References 167

17. Exercise and Nutritional Benefits for Individuals with a Spinal Cord Injury or Amputation

JUSTIN W. KEOGH

Paralympic Sport and Classification Systems 171
Review Methodology 171
Energy Expenditure and Body Composition 171
Exercise Adaptations 173
Nutritional Practices 175
Nutritional Knowledge and Education Programs 177
Supplement Usage 177
Effects of Nutrition on Body Composition and Performance 177
Conclusions and Areas for Future Research 179
References 180

CONTENTS

18. An Overview of Doping in Sports

FABIAN SANCHIS-GOMAR, VLADIMIR MARTINEZ-BELLO, HELIOS PAREJA-GALEANO, THOMAS BRIOCHE AND MARI CARMEN GÓMEZ-CABRERA

Introduction 183
Main Tendencies of Doping in the Strength
Field 184
Metabolic Modulators and Related Substances 189
Blood Doping and Anti-Doping Approaches in Endurance
Sports 190
Masking Agents 191
Gene Doping 192
References 192

19. Nutrition In Paralympics

AMITAVA DAS, DEBASIS BAGCHI AND CHANDAN K. SEN

Introduction 197
Sports Nutrition and Enhanced Performance 197
The Paralympic Games 197
Classification and Categories at the Paralympic Games 198
Nutritional Considerations in the Disabled 198
Sports Nutrition of Paralympic Athletes 199
Conclusion 202
References 202

20. An Overview on the History of Sports Nutrition Beverages

GUSTAVO A. GALAZ

Introduction 205
Background on Sports Beverages 205
History of Protein Drinks 207
Conclusion 210
References 210

IV

MOLECULAR MECHANISMS

21. α-Hydroxy-Isocaproic Acid (HICA)—Effects on Body Composition, Muscle Soreness and Athletic Performance

> TUOMO OJALA, JACOB M. WILSON, JUHA J. HULMI, TUOMO KARILA, TIMO A. SEPPÄLÄ AND ANTTI A. MERO

Background 213
Effects of Alfa-Hydroxy-Isocaproic Acid on Body Composition,
Delayed-Onset Muscle Soreness and Physical Performance in
Athletes 214
Conclusion 215
References 215

22. Role of Mammalian Target of Rapamycin (mTOR) in Muscle Growth

EVGENIY PANZHINSKIY, BRUCE CULVER, JUN REN, DEBASIS BAGCHI AND SREEIAYAN NAIR

Introduction 217

Muscle Growth 217

mTOR Signaling Pathway 218

mTOR in Myogenesis 220

mTOR in Muscle Hypertrophy 220

mTOR in Muscle Atrophy 222

Nutrition and mTOR-Dependent Muscle

Growth 223

Conclusions 223

References 224

23. Stress Proteins and Heat Shock Proteins: Role in Muscle Building and Sports Nutrition

MIKA VENOJÄRVI, NIKU OKSALA, SUSANNA KINNUNEN AND MUSTAFA ATALAY

Introduction 229
Heat Shock Protein Family 229
Regulation of Stress Proteins in Skeletal Muscle 230
Stress Proteins and Exercise 231
Stress Proteins and Dietary Supplements 232
Conclusions 233
References 233

24. Anabolic and Catabolic Signaling Pathways that Regulate Skeletal Muscle Mass

JOHN J. MCCARTHY

Introduction 237
History 237
Anabolic Signaling 238
Catabolic Signaling 241
Summary 243
References 243

25. Muscle Growth, Repair and Preservation: A Mechanistic Approach

ROBERT M. ERSKINE AND HANS DEGENS

Introduction 247 Muscle Growth 248 Muscle Atrophy 252 Muscle Damage and Repair 254 Summary 257 References 257

26. Nitric Oxide, Sports Nutrition and Muscle Building

LAWRENCE J. DRUHAN

Introduction 265 The Nitric Oxide Synthases 265 The Nitrate—Nitrite—No Pathway 266
Skeletal Muscle Functions Mediated By NO 266
Nutritional Modification Of Skeletal Muscle
Hypertrophy 269
Conclusion 270
References 270

27. Role of Nitric Oxide in Sports Nutrition

Introduction 275
Recommended Nutrition Criteria for Better Sports
Performance 276
Role of Nitric Oxide in Nutritional Supplements 277
Biochemistry of Nitrosative Protein Modifications in
Muscles 279
References 280

28. Blood Rheology, Blood Flow and Human Health

PHILIPPE CONNES, STÉPHANE DUFOUR, AURÉLIEN PICHON AND FABRICE FAVRET

Blood Flow: Characteristics, Exercise and
Training 283
Hemorheology: Interactions with Blood Flow, Exercise and
Training 285
Nutrition, Blood Flow and Blood Rheology 286
Conclusion 288
References 289

29. Genetic Aspects of Sprint, Strength and Power Performance

ERIK D HANSON AND NIR EYNON

Introduction 295
Exercise Performance and Heritability 295
Conclusions 299
Glossary 299
References 300

30. Unraveling the Function of Skeletal Muscle as a Secretory Organ

WATARU AOI, YUJI NAITO, TOMOHISA TAKAGI AND TOSHIKAZU YOSHIKAWA

Introduction 305
Bioactive Proteins Secreted from Skeletal Muscle Cells in Response to Exercise 305
Approach for Identification of New Muscle-Secreted Proteins 307
SPARC is a Cancer Preventive Protein Secreted by Skeletal Muscle 307

Perspective 308 References 309

\mathbf{V}

MINERALS AND SUPPLEMENTS IN MUSCLE BUILDING

31. The Role of Testosterone in Nutrition and Sports: An Overview

JAN LINGEN, HANDE HOFMANN AND MARTIN SCHÖNFELDER

Introduction 315
Meaning of Natural Testosterone Levels and Hypertrophy/
Muscle Growth 317
Energy Restriction, Testosterone Levels and Hypertrophy 317

Influence of Diet on Testosterone Levels 318
Influence of Protein and Carbohydrate Ingestion Post Exercise on Testosterone Levels and Hypertrophy/Body
Composition 320

Mechanisms Whereby Insulin Could Alter Testosterone Levels 320

Effect of Resistance Training Plus Dietary Supplementation on Testosterone Levels 321 References 322

32. Nutritional Interventions to Reduce Immune Suppression Post Marathon

JOHN C. BLOCHER, SONJA E. NODLAND, DON J. COX, BRIAN K. MCFARLIN, HIROYOSHI MORIYAMA AND YOSHIAKI SHIOJIMA

Upper Respiratory Tract Infections and Runners 325 Changes in Immune Biomarkers and Runners 325 Immunonutrition Support and Long-Distance Running 327 Conclusions and Recommendations 329 References 330

33. Carbohydrate and Muscle Glycogen Metabolism: Exercise Demands and Nutritional Influences

Carbohydrate Utilization During Exercise 333 Conclusion 339 References 340

34. An Overview of Adaptogens with a Special Emphasis on Withania and Rhodiola

PRANAY WAL AND ANKITA WAL

Introduction 343 Withania as Adaptogen 344 Rhodiola as Adaptogen 345 References 348 CONTENTS

35. Anabolic Training Response and Clinical Implications IAN SUNDELL

Introduction 351 Resistance Training 351 Nutrition 351 Clinical Aspects 352 References 353

36. Requirements of Energy, Carbohydrates, Proteins, and Fats for Athletes

CHAD M. KERKSICK AND MICHELLE KULOVITZ

Energy Requirements 355 Carbohydrates 357 Protein 360 Fats 362 Conclusions 364 References 364

37. An Overview of Branched-Chain Amino Acids in Exercise and Sports Nutrition

HUMBERTO NICASTRO, DANIELA FOJO SEIXAS CHAVES AND ANTONIO HERBERT LANCHA JR

Introduction 367
Amino Acids Metabolism in Skeletal Muscle 368
Molecular Pathways of Amino Acids in Skeletal Muscle 369
Effects of Amino Acids Supplementation on Muscle Mass and Strength 370
Dietary Sources and Practical Application of Protein Supplementation 372
Amino Acids—Practical Recommendations 373
Conclusion and Perspectives 374
References 375

38. Water, Hydration and Sports Drink

FLAVIA MEYER, BRIAN WELDON TIMMONS AND BOGUSLAW WILK

Introduction 377
Effects of Hypohydration 377
Special Populations 379
Hydration for Physical Activities 380
Conclusions 382
References 382

39. Physiological Basis for Creatine Supplementation in Skeletal Muscle

WILLIAM J. KRAEMER, HUI-YING LUK, JOEL R. LOMBARD, COURTENAY DUNN-LEWIS AND JEFF S. VOLEK

Introduction/Overview 385
Creatine Biosynthesis, Uptake, and Degradation 385
Bioenergetics and Mechanisms of Action 387
Limits of Creatine Storage Capacity with
Supplementation 387

Body Mass, Body Composition, and Body Water 387
Muscle Fiber Type Adaptations 388
Acute Anaerobic Benefits 388
Chronic Anaerobic Adaptations 388
Endurance Exercise Acute Effects and Adaptation 390
Role of Creatine Supplementation for use to Combat Aging 392
Therapeutic use of Creatine Supplementation 392
Summary 393
References 393

хi

40. Oral Bioavailability of Creatine Supplements

DONALD W. MILLER, SAMUEL AUGUSTINE, DENNIS H. ROBINSON, JONATHAN L. VENNERSTROM AND JON C. WAGNER

Introduction 395
Cellular Mechanism of Intestinal Absorption 396
Creatine Absorption in the GIT 397
Human Oral Bioavailability of Creatine Supplements 398
Absorption Characteristics of Alternative Forms of Creatine 399
Conclusions 401
References 401

41. An Overview of Carnitine

RICHARD J. BLOOMER, TYLER M. FARNEY AND MATTHEW J. MCALLISTER

Introduction 405
Antioxidant Activity 406
Nitric Oxide 406
Exercise Performance-Related Variables 407
Summary of Carnitine for Athletic Populations 409
Overview of Carnitine for Non-Athletic (Healthy and Diseased)
Populations 410
Conclusions 410
References 410

42. An Overview of the Influence of Protein Ingestion on Muscle Hypertrophy KOII OKAMURA

The Importance of Dietary Energy 415
Protein Requirements 415
Habitual High Protein Intake 416
Amino Acids 417
Absorption Rate 418
Co-Ingestion of Protein with Carbohydrate 419
Ingestion Timing 419
References 420

43. An Overview of Ornithine, Arginine and Citrulline in Exercise and Sports Nutrition KOHEI TAKEDA AND TOHRU TAKEMASA

Introduction 423
Ornithine, Arginine and Citrulline: Biogenesis and
Metabolism 423

Nitric Oxide Synthesis and its Function in the Body 424
Effects of Ornithine, Arginine and Citrulline Supplementation on
Nitric Oxide Synthesis and Performance 424
Exercise and Ammonia 425
Effects of Ornithine, Arginine and Citrulline Supplementation on
Ammonia and Performance 426
Other Effects of Ornithine, Arginine and Citrulline
Supplementation 428
Conclusion 429
References 429

44. An Overview of Glycine-Arginine-Alpha-Ketoisocaproic Acid (GAKIC) in Sports Nutrition

BRUCE R. STEVENS

Introduction 433
Isokinetic Dynamometer Studies 433
Cycle Ergometry Studies 434
KIC Monotherapy 435
Metabolism 435
Conclusion 437
References 438

45. L-Arginine and L-Citrulline in Sports Nutrition and Health

RACHEL BOTCHLETT, JOHN M. LAWLER AND GUOYAO WU

Introduction 439 Arginine 439 Citrulline 443 Conclusion 444 References 445

46. Roles of Chromium(III), Vanadium, and Zinc in Sports Nutrition

IOHN B. VINCENT AND YASMIN NEGGERS

Introduction 447 Vanadium 447 Chromium 448 Zinc 451 Conclusion 453 References 453

47. An Overview on Beta-hydroxy-betamethylbutyrate (HMB) Supplementation in Skeletal Muscle Function and Sports Performance

CARLOS HERMANO J. PINHEIRO, LUCAS GUIMARÃES-FERREIRA, FREDERICO GERLINGER-ROMERO AND RUI CURI

Introduction 455
An Overview on HMB Metabolism 455
HMB Supplementation 456
Effects of HMB Supplementation on Strength and Body
Composition 457

Mechanisms of Action of HMB 458 HMB on Protein Homeostasis in Skeletal Muscle 458 Conclusion 461 References 461

48. Role of Astaxanthin in Sports Nutrition BOB CAPELLI, USHA JENKINS AND GERALD R. CYSEWSKI

Introduction 465
Benefits of Astaxanthin for Athletes 465
Conclusions 470
References 470

49. Ursolic Acid and Maslinic Acid

Introduction 473 Ursolic Acid 473 Maslinic Acid 476 Conclusions 477 References 477

50. Plant Borates and Potential Uses to Promote Post-training Recovery and to Mitigate Overtraining Syndrome

ZBIGNIEW PIETRZKOWSKI, JOHN HUNTER, BRAD EVERS AND HARTLEY POND

Introduction 479
The Trace Element Boron, Borates and Boro-Carbohydrates 480
Myokines, Inflammation, Recovery and Overtraining
Syndrome 480
Inflammation 481
Exercise and Inflammation 481
Biological Potency of Calcium Fructoborate 482
Summary 483
References 483

51. An Overview on Caffeine BRITTANIE M. VOLK AND BRENT C. CREIGHTON

Introduction 487
Caffeine Pharmacology 487
Mechanisms of Caffeine and Effects on Performance 488
Sources of Caffeine 491
Safety and Side Effects 492
Summary 493
References 493

52. Role of Quercetin in Sports Nutrition JOHN SEIFERT

Chemistry 497 Performance 497 CONTENTS xiii

Mitochondrial Biogenesis 498 Immune & Inflammatory Responses 499 Future Research Areas 499 Conclusions 500 References 500

53. Human Performance and Sports Applications of Tongkat Ali (Eurycoma longifolia)

SHAWN M. TALBOTT

Traditional Use 501
Modern Extracts 501
Laboratory and Animal Research 502
Human-Feeding Trials 502
Safety 503
Summary 503
References 504

VI

DIETARY RECOMMENDATIONS

54. Nutrition and Dietary Recommendations for Bodybuilders

PHILIP E. APONG

Introduction 509
Protein Requirements for the Bodybuilder 510
Protein Type and Digestibly 511
Protein Timing for Bodybuilders 514
Protein Dose Per Meal 515
Energy Requirements 515

Carbohydrates 516 Fats 517 Conclusion 517 References 518

55. Performance Nutrition for Young Athletes JOHNERIC W. SMITH AND ASKER JEUKENDRUP

Introduction 523
Carbohydrate 524
Protein 525
Fat 525
Micronutrients 526
Hydration 526
Supplements 527
Gaps in Our Knowledge 527
Putting it all Together 527
References 528

VII

CONCLUDING REMARKS

56. Commentary
DEBASIS BAGCHI, SREEJAYAN NAIR AND CHANDAN K. SEN

Index 535 Color Plates