

Contents

Foreword by Sir Clive Woodward	xiii		
Preface	xv		
List of Contributors	xvii		
Section 1 Strength and Conditioning Biology	1		
1.1 Skeletal Muscle Physiology	3		
<i>Valmor Tricoli</i>			
1.1.1 Introduction	3		
1.1.2 Skeletal Muscle Macrostructure	3		
1.1.3 Skeletal Muscle Microstructure	3		
1.1.3.1 Sarcomere and myofilaments	4		
1.1.3.2 Sarcoplasmic reticulum and transverse tubules	7		
1.1.4 Contraction Mechanism	7		
1.1.4.1 Excitation-contraction (E-C) coupling	7		
1.1.4.2 Skeletal muscle contraction	7		
1.1.5 Muscle Fibre Types	9		
1.1.6 Muscle Architecture	10		
1.1.7 Hypertrophy and Hyperplasia	11		
1.1.8 Satellite Cells	12		
1.2 Neuromuscular Physiology	17		
<i>Alberto Rainoldi and Marco Gazzoni</i>			
1.2.1 The Neuromuscular System	17		
1.2.1.1 Motor units	17		
1.2.1.2 Muscle receptors	17		
1.2.1.3 Nervous and muscular conduction velocity	18		
1.2.1.4 Mechanical output production	18		
1.2.1.5 Muscle force modulation	20		
1.2.1.6 Electrically elicited contractions	22		
1.2.2 Muscle Fatigue	22		
1.2.2.1 Central and peripheral fatigue	22		
1.2.2.2 The role of oxygen availability in fatigue development	23		
1.2.3 Muscle Function Assessment	23		
1.2.3.1 Imaging techniques	23		
1.2.3.2 Surface EMG as a muscle imaging tool	24		
		1.2.3.3 Surface EMG for noninvasive neuromuscular assessment	25
		1.3 Bone Physiology	29
		<i>Jörn Rittweger</i>	
		1.3.1 Introduction	29
		1.3.2 Bone Anatomy	29
		1.3.2.1 Bones as organs	29
		1.3.2.2 Bone tissue	30
		1.3.2.3 The material level: organic and inorganic constituents	31
		1.3.3 Bone Biology	32
		1.3.3.1 Osteoclasts	32
		1.3.3.2 Osteoblasts	32
		1.3.3.3 Osteocytes	33
		1.3.4 Mechanical Functions of Bone	33
		1.3.4.1 Material properties	33
		1.3.4.2 Structural properties	34
		1.3.5 Adaptive Processes in Bone	35
		1.3.5.1 Modelling	35
		1.3.5.2 Remodelling	35
		1.3.5.3 Theories of bone adaptation	36
		1.3.5.4 Mechanotransduction	37
		1.3.6 Endocrine Involvement of Bone	38
		1.3.6.1 Calcium homoeostasis	38
		1.3.6.2 Phosphorus homoeostasis	38
		1.3.6.3 Oestrogens	38
		1.4 Tendon Physiology	45
		<i>Nicola Maffulli, Umile Giuseppe Longo, Filippo Spiezia and Vincenzo Denaro</i>	
		1.4.1 Tendons	45
		1.4.2 The Musculotendinous Junction	46
		1.4.3 The Oseotendinous Junction	46
		1.4.4 Nerve Supply	46
		1.4.5 Blood Supply	46
		1.4.6 Composition	47
		1.4.7 Collagen Formation	47
		1.4.8 Cross-Links	47
		1.4.9 Elastin	48
		1.4.10 Cells	48

1.4.11	Ground Substance	48	1.7.2.6	Signalling associated with muscle protein breakdown	83
1.4.12	Crimp	48	1.7.2.7	Satellite-cell regulation during strength training	84
1.5	Bioenergetics of Exercise	53	1.7.2.8	What we have not covered	84
	<i>Ron J. Maughan</i>		1.8	Strength and Conditioning	
1.5.1	Introduction	53		Biomechanics	89
1.5.2	Exercise, Energy, Work, and Power	53		<i>Robert U. Newton</i>	
1.5.3	Sources of Energy	54	1.8.1	Introduction	89
1.5.3.1	Phosphagen metabolism	55	1.8.1.1	Biomechanics and sport	89
1.5.3.2	The glycolytic system	56	1.8.2	Biomechanical Concepts for Strength and Conditioning	89
1.5.3.3	Aerobic metabolism: oxidation of carbohydrate, lipid, and protein	57	1.8.2.1	Time, distance, velocity, and acceleration	90
1.5.4	The Tricarboxylic Acid (TCA) Cycle	57	1.8.2.2	Mass, force, gravity, momentum, work, and power	90
1.5.5	Oxygen Delivery	58	1.8.2.3	Friction	91
1.5.6	Energy Stores	58	1.8.3	The Force–Velocity–Power Relationship	91
1.5.7	Conclusion	60	1.8.4	Musculoskeletal Machines	92
1.6	Respiratory and Cardiovascular Physiology	63	1.8.4.1	Lever systems	92
	<i>Jeremiah J. Peiffer and Chris R. Abbiss</i>		1.8.4.2	Wheel-axle systems	93
1.6.1	The Respiratory System	63	1.8.5	Biomechanics of Muscle Function	93
1.6.1.1	Introduction	63	1.8.5.1	Length–tension effect	93
1.6.1.2	Anatomy	63	1.8.5.2	Muscle angle of pull	93
1.6.1.3	Gas exchange	63	1.8.5.3	Strength curve	94
1.6.1.4	Mechanics of ventilation	66	1.8.5.4	Line and magnitude of resistance	95
1.6.1.5	Minute ventilation	67	1.8.5.5	Sticking region	95
1.6.1.6	Control of ventilation	68	1.8.5.6	Muscle architecture, strength, and power	95
1.6.2	The Cardiovascular System	68	1.8.5.7	Multiarticulate muscles, active and passive insufficiency	96
1.6.2.1	Introduction	68	1.8.6	Body Size, Shape, and Power-To-Weight Ratio	96
1.6.2.2	Anatomy	68	1.8.7	Balance and Stability	96
1.6.2.3	The heart	70	1.8.7.1	Factors contributing to stability	96
1.6.2.4	The vascular system	71	1.8.7.2	Initiating movement or change of motion	97
1.6.2.5	Blood and haemodynamics	72	1.8.8	The Stretch–Shortening Cycle	97
1.6.3	Conclusion	74	1.8.9	Biomechanics of Resistance Machines	98
1.7	Genetic and Signal Transduction Aspects of Strength Training	77	1.8.9.1	Free weights	98
	<i>Henning Wackerhage, Arimantas Lionikas, Stuart Gray and Aivaras Ratkevicius</i>		1.8.9.2	Gravity-based machines	98
1.7.1	Genetics of Strength and Trainability	77	1.8.9.3	Hydraulic resistance	99
1.7.1.1	Introduction to sport and exercise genetics	77	1.8.9.4	Pneumatic resistance	99
1.7.1.2	Heritability of muscle mass, strength, and strength trainability	77	1.8.9.5	Elastic resistance	100
1.7.2	Signal Transduction Pathways that Mediate the Adaptation to Strength Training	79	1.8.10	Machines vs Free Weights	100
1.7.2.1	Introduction to adaptation to exercise: signal transduction pathway regulation	79	1.8.11	Conclusion	100
1.7.2.2	Human protein synthesis and breakdown after exercise	80	Section 2	Physiological adaptations to strength and conditioning	103
1.7.2.3	The AMPK–mTOR system and the regulation of protein synthesis	81	2.1	Neural Adaptations to Resistance Exercise	105
1.7.2.4	Potential practical implications	82		<i>Per Aagaard</i>	
1.7.2.5	Myostatin–Smad signalling	83	2.1.1	Introduction	105
			2.1.2	Effects of Strength Training on Mechanical Muscle Function	105

2.1.2.1	Maximal concentric and eccentric muscle strength	105	2.4	Biochemical Markers and Resistance Training	155
2.1.2.2	Muscle power	106		<i>Christian Cook and Blair Crewther</i>	
2.1.2.3	Contractile rate of force development	107	2.4.1	Introduction	155
2.1.3	Effects of Strength Training on Neural Function	107	2.4.2	Testosterone Responses to Resistance Training	155
2.1.3.1	Maximal EMG amplitude	108	2.4.2.1	Effects of workout design	155
2.1.3.2	Contractile RFD: changes in neural factors with strength training	109	2.4.2.2	Effects of age and gender	156
2.1.3.3	Maximal eccentric muscle contraction: changes in neural factors with strength training	110	2.4.2.3	Effects of training history	156
2.1.3.4	Evoked spinal motor neuron responses	114	2.4.3	Cortisol Responses to Resistance Training	156
2.1.3.5	Excitability in descending corticospinal pathways	116	2.4.3.1	Effects of workout design	156
2.1.3.6	Antagonist muscle coactivation	116	2.4.3.2	Effects of age and gender	157
2.1.3.7	Force steadiness, fine motor control	119	2.4.3.3	Effects of training history	157
2.1.4	Conclusion	119	2.4.4	Dual Actions of Testosterone and Cortisol	157
2.2	Structural and Molecular Adaptations to Training	125	2.4.5	Growth Hormone Responses to Resistance Training	157
	<i>Jesper L. Andersen</i>		2.4.5.1	Effects of workout design	158
2.2.1	Introduction	125	2.4.5.2	Effects of age and gender	158
2.2.2	Protein Synthesis and Degradation in Human Skeletal Muscle	125	2.4.5.3	Effects of training history	158
2.2.3	Muscle Hypertrophy and Atrophy	127	2.4.6	Other Biochemical Markers	158
2.2.3.1	Changes in fibre type composition with strength training	128	2.4.7	Limitations in the Use and Interpretation of Biochemical Markers	159
2.2.4	What is the Significance of Satellite Cells in Human Skeletal Muscle?	131	2.4.8	Applications of Resistance Training	159
2.2.5	Concurrent Strength and Endurance Training: Consequences for Muscle Adaptations	132	2.4.9	Conclusion	160
2.3	Adaptive Processes in Human Bone and Tendon	137	2.5	Cardiovascular Adaptations to Strength and Conditioning	165
	<i>Constantinos N. Maganaris, Jörn Rittweger and Marco V. Narici</i>			<i>Andrew M. Jones and Fred J. DiMenna</i>	
2.3.1	Introduction	137	2.5.1	Introduction	165
2.3.2	Bone	137	2.5.2	Cardiovascular Function	165
2.3.2.1	Origin of musculoskeletal forces	137	2.5.2.1	Oxygen uptake	165
2.3.2.2	Effects of immobilization on bone	138	2.5.2.2	Maximal oxygen uptake	165
2.3.2.3	Effects of exercise on bone	140	2.5.2.3	Cardiac output	165
2.3.2.4	Bone adaptation across the life span	140	2.5.2.4	Cardiovascular overload	166
2.3.3	Tendon	141	2.5.2.5	The cardiovascular training stimulus	167
2.3.3.1	Functional and mechanical properties	141	2.5.2.6	Endurance exercise training	167
2.3.3.2	<i>In vivo</i> testing	143	2.5.3	Cardiovascular Adaptations to Training	167
2.3.3.3	Tendon adaptations to altered mechanical loading	143	2.5.3.1	Myocardial adaptations to endurance training	167
2.3.4	Conclusion	147	2.5.3.2	Circulatory adaptations to endurance training	170
			2.5.4	Cardiovascular-Related Adaptations to Training	172
			2.5.4.1	The pulmonary system	172
			2.5.4.2	The skeletal muscular system	173
			2.5.5	Conclusion	174
			2.6	Exercise-induced Muscle Damage and Delayed-onset Muscle Soreness (DOMS)	179
				<i>Kazunori Nosaka</i>	
			2.6.1	Introduction	179
			2.6.2	Symptoms and Markers of Muscle Damage	179

2.6.2.1	Symptoms	179	2.7.3.7	Applications in rehabilitation	203
2.6.2.2	Histology	179	2.7.3.8	Safety considerations	203
2.6.2.3	MRI and B-mode ultrasound images	180	2.8	The Stretch–Shortening Cycle (SSC)	209
2.6.2.4	Blood markers	180		<i>Anthony Blazevich</i>	
2.6.2.5	Muscle function	181	2.8.1	Introduction	209
2.6.2.6	Exercise economy	182	2.8.2	Mechanisms Responsible for Performance Enhancement with the SSC	209
2.6.2.7	Range of motion (ROM)	182		2.8.2.1 Elastic mechanisms	209
2.6.2.8	Swelling	182		2.8.2.2 Contractile mechanisms	212
2.6.2.9	Muscle pain	183		2.8.2.3 Summary of mechanisms	216
2.6.3	Relationship between Doms and Other Indicators	184	2.8.3	Force Unloading: A Requirement for Elastic Recoil	216
2.6.4	Factors Influencing the Magnitude of Muscle Damage	184	2.8.4	Optimum MTU Properties for SSC Performance	217
	2.6.4.1 Contraction parameters	185	2.8.5	Effects of the Transition Time between Stretch and Shortening on SSC Performance	218
	2.6.4.2 Training status	185	2.8.6	Conclusion	218
	2.6.4.3 Repeated-bout effect	185	2.9	Repeated-sprint Ability (RSA)	223
	2.6.4.4 Muscle	186		<i>David Bishop and Olivier Girard</i>	
	2.6.4.5 Other factors	186	2.9.1	Introduction	223
2.6.5	Muscle Damage and Training	187		2.9.1.1 Definitions	223
	2.6.5.1 The importance of eccentric contractions	187		2.9.1.2 Indices of RSA	223
	2.6.5.2 The possible role of muscle damage in muscle hypertrophy and strength gain	187	2.9.2	Limiting Factors	223
	2.6.5.3 No pain, no gain?	188		2.9.2.1 Muscular factors	224
2.6.6	Conclusion	188		2.9.2.2 Neuromechanical factors	227
2.7	Alternative Modalities of Strength and Conditioning: Electrical Stimulation and Vibration	193		2.9.2.3 Summary	229
	<i>Nicola A. Maffiuletti and Marco Cardinale</i>		2.9.3	Ergogenic aids and RSA	229
2.7.1	Introduction	193		2.9.3.1 Creatine	230
2.7.2	Electrical-Stimulation Exercise	193		2.9.3.2 Carbohydrates	230
	2.7.2.1 Methodological aspects: ES parameters and settings	193		2.9.3.3 Alkalizing agents	230
	2.7.2.2 Physiological aspects: motor unit recruitment and muscle fatigue	194		2.9.3.4 Caffeine	231
	2.7.2.3 Does ES training improve muscle strength?	195		2.9.3.5 Summary	232
	2.7.2.4 Could ES training improve sport performance?	196	2.9.4	Effects of Training on RSA	232
	2.7.2.5 Practical suggestions for ES use	196		2.9.4.1 Introduction	232
2.7.3	Vibration Exercise	197		2.9.4.2 Training the limiting factors	232
	2.7.3.1 Is vibration a natural stimulus?	200		2.9.4.3 Putting it all together	235
	2.7.3.2 Vibration training is not just about vibrating platforms	201	2.9.5	Conclusion	235
	2.7.3.3 Acute effects of vibration in athletes	201	2.10	The Overtraining Syndrome (OTS)	243
	2.7.3.4 Acute effects of vibration exercise in non-athletes	202		<i>Romain Meeusen and Kevin De Pauw</i>	
	2.7.3.5 Chronic programmes of vibration training in athletes	202	2.10.1	Introduction	243
	2.7.3.6 Chronic programmes of vibration training in non-athletes	203	2.10.2	Definitions	243
				2.10.2.1 Functional overreaching (FO)	243
				2.10.2.2 Nonfunctional overreaching (NFO)	244
				2.10.2.3 The overtraining syndrome (OTS)	244
				2.10.2.4 Summary	244
			2.10.3	Prevalence	244
			2.10.4	Mechanisms and Diagnosis	245
				2.10.4.1 Hypothetical mechanisms	245
				2.10.4.2 Biochemistry	245

2.10.4.3	Physiology	245		
2.10.4.4	The immune system	246		
2.10.4.5	Hormones	246		
2.10.4.6	Is the brain involved?	246		
2.10.4.7	Training status	247		
2.10.4.8	Psychometric measures	247		
2.10.4.9	Psychomotor speed	247		
2.10.4.10	Are there definitive diagnostic criteria?	248		
2.10.5	Prevention	248		
2.10.6	Conclusion	249		
Section 3 Monitoring strength and conditioning progress 253				
3.1	Principles of Athlete Testing	255		
	<i>Robert U. Newton, Prue Cormie and Marco Cardinale</i>			
3.1.1	Introduction	255		
3.1.2	General Principles of Testing Athletes	255		
3.1.2.1	Validity	255		
3.1.2.2	Reliability	255		
3.1.2.3	Specificity	255		
3.1.2.4	Scheduling	256		
3.1.2.5	Selection of movement tested	256		
3.1.2.6	Stretching and other preparation for the test	256		
3.1.3	Maximum Strength	257		
3.1.3.1	Isoinertial strength testing	257		
3.1.3.2	Isometric strength testing	258		
3.1.3.3	Isokinetic strength testing	259		
3.1.4	Ballistic Testing	259		
3.1.4.1	Jump squats	260		
3.1.4.2	Rate of force development (RFD)	261		
3.1.4.3	Temporal phase analysis	261		
3.1.4.4	Equipment and analysis methods for ballistic testing	264		
3.1.5	Reactive Strength Tests	265		
3.1.6	Eccentric Strength Tests	266		
3.1.6.1	Specific tests of skill performance	267		
3.1.6.2	Relative or absolute measures	267		
3.1.7	Conclusion	267		
3.2	Speed and Agility Assessment	271		
	<i>Warren Young and Jeremy Sheppard</i>			
3.2.1	Speed	271		
3.2.1.1	Introduction	271		
3.2.1.2	Testing acceleration speed	271		
3.2.1.3	Testing maximum speed	272		
3.2.1.4	Testing speed endurance	272		
3.2.1.5	Standardizing speed-testing protocols	273		
3.2.2	Agility	273		
3.2.3	Conclusion	275		
3.3	Testing Anaerobic Capacity and Repeated-sprint Ability	277		
	<i>David Bishop and Matt Spencer</i>			
3.3.1	Introduction	277		
3.3.1.1	Energy systems	277		
3.3.1.2	The importance of anaerobic capacity and RSA	277		
3.3.2	Testing Anaerobic Capacity	277		
3.3.2.1	Definition	277		
3.3.2.2	Assessment	279		
3.3.3	Testing Repeated-Sprint Ability	284		
3.3.3.1	Definition	284		
3.3.3.2	Assessment	284		
3.3.4	Conclusion	286		
3.4	Cardiovascular Assessment and Aerobic Training Prescription	291		
	<i>Andrew M. Jones and Fred J. DiMenna</i>			
3.4.1	Introduction	291		
3.4.2	Cardiovascular Assessment	291		
3.4.2.1	Health screening and risk stratification	291		
3.4.2.2	Cardiorespiratory fitness and VO_{2max}	291		
3.4.2.3	Submaximal exercise testing	292		
3.4.2.4	Maximal exercise testing	292		
3.4.3	Aerobic Training Prescription	297		
3.4.3.1	Specificity and aerobic overload	297		
3.4.3.2	Mode	297		
3.4.3.3	Frequency	297		
3.4.3.4	Total volume	298		
3.4.3.5	Intensity	298		
3.4.3.6	Total volume vs volume per unit time	298		
3.4.3.7	Progression	299		
3.4.3.8	Reversibility	299		
3.4.3.9	Parameter-specific cardiorespiratory enhancement	299		
3.4.3.10	VO_{2max} improvement	299		
3.4.3.11	Exercise economy improvement	300		
3.4.3.12	LT/LTP improvement	300		
3.4.3.13	VO_2 kinetics improvement	300		
3.4.3.14	Prescribing exercise for competitive athletes	301		
3.4.4	Conclusion	301		
3.5	Biochemical Monitoring in Strength and Conditioning	305		
	<i>Michael R. McGuigan and Stuart J. Cormack</i>			
3.5.1	Introduction	305		
3.5.2	Hormonal Monitoring	305		
3.5.2.1	Cortisol	305		
3.5.2.2	Testosterone	305		
3.5.2.3	Catecholamines	306		
3.5.2.4	Growth hormone	306		

3.5.2.5	IGF	306	3.7.2.7	Presenting the results	340
3.5.2.6	Leptin	307	3.7.2.8	Sophisticated is not necessarily expensive	340
3.5.2.7	Research on hormones in sporting environments	307	3.7.2.9	Recent advances and the future	341
3.5.2.8	Methodological considerations	308	3.7.3	Conclusion	342
3.5.3	Metabolic Monitoring	308	Section 4	Practical applications	345
3.5.3.1	Muscle biopsy	308	4.1	Resistance Training Modes: A Practical Perspective	347
3.5.3.2	Biochemical testing	309		<i>Michael H. Stone and Margaret E. Stone</i>	
3.5.4	Immunological and Haematological Monitoring	309	4.1.1	Introduction	347
3.5.4.1	Immunological markers	309	4.1.2	Basic Training Principles	348
3.5.4.2	Haematological markers	310	4.1.2.1	Overload	348
3.5.5	Practical Application	310	4.1.2.2	Variation	348
3.5.5.1	Evaluating the effects of training	310	4.1.2.3	Specificity	348
3.5.5.2	Assessment of training workload	311	4.1.3	Strength, Explosive Strength, and Power	348
3.5.5.3	Monitoring of fatigue	311	4.1.3.1	Joint-angle specificity	349
3.5.5.4	Conclusions and specific advice for implementation of a biochemical monitoring programme	311	4.1.3.2	Movement-pattern specificity	350
3.6	Body Composition: Laboratory and Field Methods of Assessment	317	4.1.3.3	Machines vs free weights	351
	<i>Arthur Stewart and Tim Ackland</i>		4.1.3.4	Practical considerations: advantages and disadvantages associated with different modes of training	355
3.6.1	Introduction	317	4.1.4	Conclusion	357
3.6.2	History of Body Composition Methods	317	4.2	Training Agility and Change-of-direction Speed (CODS)	363
3.6.3	Fractionation Models for Body Composition	317		<i>Jeremy Sheppard and Warren Young</i>	
3.6.4	Biomechanical Imperatives for Sports Performance	318	4.2.1	Factors Affecting Agility	363
3.6.5	Methods of Assessment	319	4.2.2	Organization of Training	363
3.6.5.1	Laboratory methods	319	4.2.3	Change-of-Direction Speed	364
3.6.5.2	Field methods	323	4.2.3.1	Leg-strength qualities and CODS	366
3.6.6	Profiling	330	4.2.3.2	Technique	366
3.6.7	Conclusion	330	4.2.3.3	Anthropometrics and CODS	369
3.7	Total Athlete Management (TAM) and Performance Diagnosis	335	4.2.4	Perceptual and Decision-Making Factors	370
	<i>Robert U. Newton and Marco Cardinale</i>		4.2.5	Training Agility	371
3.7.1	Total Athlete Management	335	4.2.6	Conclusion	374
3.7.1.1	Strength and conditioning	335	4.3	Nutrition for Strength Training	377
3.7.1.2	Nutrition	335		<i>Christopher S. Shaw and Kevin D. Tipton</i>	
3.7.1.3	Rest and recovery	336	4.3.1	Introduction	377
3.7.1.4	Travel	336	4.3.2	The Metabolic Basis of Muscle Hypertrophy	377
3.7.2	Performance Diagnosis	336	4.3.3	Optimal Protein Intake	377
3.7.2.1	Optimizing training-programme design and the window of adaptation	337	4.3.3.1	The importance of energy balance	378
3.7.2.2	Determination of key performance characteristics	338	4.3.4	Acute Effects of Amino Acid/Protein Ingestion	379
3.7.2.3	Testing for specific performance qualities	339	4.3.4.1	Amino acid source	379
3.7.2.4	What to look for	339	4.3.4.2	Timing	381
3.7.2.5	Assessing imbalances	339	4.3.4.3	Dose	382
3.7.2.6	Session rating of perceived exertion	340	4.3.4.4	Co-ingestion of other nutrients	382

4.3.4.5 Protein supplements	383	5.1.3.5 Training of sport-specific movements	422
4.3.4.6 Other supplements	383	5.1.4 Conclusion	423
4.3.5 Conclusion	383		
4.4 Flexibility	389	5.2 Strength Training for Children and Adolescents	427
<i>William A. Sands</i>		<i>Avery D. Faigenbaum</i>	
4.4.1 Definitions	389	5.2.1 Introduction	427
4.4.2 What is Stretching?	390	5.2.2 Risks and Concerns Associated with Youth Strength Training	427
4.4.3 A Model of Effective Movement: The Integration of Flexibility and Strength	393	5.2.3 The Effectiveness of Youth Resistance Training	429
		5.2.3.1 Persistence of training-induced strength gains	429
4.5 Sensorimotor Training	399	5.2.3.2 Programme evaluation and testing	429
<i>Urs Granacher, Thomas Muehlbauer, Wolfgang Taube, Albert Gollhofer and Markus Gruber</i>		5.2.4 Physiological Mechanisms for Strength Development	430
4.5.1 Introduction	399	5.2.5 Potential Health and Fitness Benefits	430
4.5.2 The Importance of Sensorimotor Training to the Promotion of Postural Control and Strength	400	5.2.5.1 Cardiovascular risk profile	431
4.5.3 The Effects of Sensorimotor Training on Postural Control and Strength	401	5.2.5.2 Bone health	431
4.5.3.1 Sensorimotor training in healthy children and adolescents	401	5.2.5.3 Motor performance skills and sports performance	432
4.5.3.2 Sensorimotor training in healthy adults	401	5.2.5.4 Sports-related injuries	432
4.5.3.3 Sensorimotor training in healthy seniors	401	5.2.6 Youth Strength-Training Guidelines	432
4.5.4 Adaptive Processes Following Sensorimotor Training	402	5.2.6.1 Choice and order of exercise	433
4.5.5 Characteristics of Sensorimotor Training	402	5.2.6.2 Training intensity and volume	434
4.5.5.1 Activities	402	5.2.6.3 Rest intervals between sets and exercises	434
4.5.5.2 Load dimensions	403	5.2.6.4 Repetition velocity	435
4.5.5.3 Supervision	405	5.2.6.5 Training frequency	435
4.5.5.4 Efficiency	405	5.2.6.6 Programme variation	435
4.5.6 Conclusion	406	5.2.7 Conclusion	435
		Acknowledgements	435
Section 5 Strength and Conditioning special cases	411	5.3 Strength and Conditioning Considerations for the Paralympic Athlete	441
5.1 Strength and Conditioning as a Rehabilitation Tool	413	<i>Mark Jarvis, Matthew Cook and Paul Davies</i>	
<i>Andreas Schlumberger</i>		5.3.1 Introduction	441
5.1.1 Introduction	413	5.3.2 Programming Considerations	441
5.1.2 Neuromuscular Effects of Injury as a Basis for Rehabilitation Strategies	414	5.3.3 Current Controversies in Paralympic Strength and Conditioning	442
5.1.3 Strength and Conditioning in Retraining of the Neuromuscular System	415	5.3.4 Specialist Equipment	443
5.1.3.1 Targeted muscle overloading: criteria for exercise choice	415	5.3.5 Considerations for Specific Disability Groups	443
5.1.3.2 Active lengthening/eccentric training	417	5.3.5.1 Spinal-cord injuries	443
5.1.3.3 Passive lengthening/stretching	419	5.3.5.2 Amputees	445
5.1.3.4 Training of the muscles of the lumbopelvic hip complex	421	5.3.5.3 Cerebral palsy	446
		5.3.5.4 Visual impairment	447
		5.3.5.5 Intellectual disabilities	448
		5.3.5.6 Les autres	449
		5.3.6 Tips for More Effective Programming	449
		Index	453