

# Contents

<b>Preface</b>	<b>xi</b>
<b>Acknowledgments</b>	<b>xv</b>
<b>Part One Biomechanical Concepts</b>	<b>1</b>
<b>1 Joint Torque</b>	<b>3</b>
1.1 Elements of history	3
1.2 What are the joint torques/moments?	4
1.3 Joint moments in statics and dynamics	12
1.4 The bottom line	21
References	23
<b>2 Stiffness and Stiffness-like Measures</b>	<b>25</b>
2.1 Elements of history	25
2.2 The concept of stiffness	26
2.3 Elastic properties of muscles and tendons	30
2.4 Apparent stiffness of joints and kinematic chains	40
2.5 The bottom line	44
References	46
<b>3 Velocity-Dependent Resistance</b>	<b>49</b>
3.1 Viscosity in physics	49
3.2 Elements of history: muscle viscosity theory and its collapse	50
3.3 On muscle and joint viscosity—comments on the terminology	53
3.4 Velocity-dependent resistance of the passive objects—synovial fluid, tendons, passive muscles, and joints	54
3.5 Velocity-dependent resistance of the active objects—muscles, joints, kinematic chains	55
3.6 More on muscle viscosity	58
3.7 Mechanical impedance	58
3.8 A comment on clinical terminology	60
3.9 The bottom line	60
References	61

<b>4</b>	<b>Mechanical Work and Energy</b>	<b>63</b>
4.1	Elements of history	64
4.2	Definitions of work and power—work of a muscle	65
4.3	Work and power in human movements	66
4.4	Energy saving mechanisms	69
4.5	The bottom line	81
	References	81
 <b>Part Two Neurophysiological Concepts</b>		 <b>83</b>
<b>5</b>	<b>Muscle Tone</b>	<b>85</b>
5.1	Elements of history	85
5.2	Current definitions	86
5.3	Relation of muscle tone to the tonic stretch reflex	88
5.4	Muscle tone and ability to relax	91
5.5	Factors causing “low muscle tone”	92
5.6	Factor causing “high muscle tone”	94
5.7	The bottom line	96
	References	97
<b>6</b>	<b>Reflexes</b>	<b>99</b>
6.1	Elements of history	99
6.2	Current definitions of reflex	100
6.3	Preferred definition of reflex	102
6.4	Classifications of reflexes	103
6.5	Examples of commonly studied reflexes in humans	108
6.6	The role of reflexes in movements	112
6.7	Pathological reflexes	117
6.8	The bottom line	118
	References	119
<b>7</b>	<b>Preprogrammed Reactions</b>	<b>121</b>
7.1	Elements of history	121
7.2	Current terminology	122
7.3	Definition and origins of preprogrammed reactions	124
7.4	Examples of commonly studied preprogrammed reactions	127
7.5	The role of preprogrammed reactions in movements	132
7.6	Atypical preprogrammed reactions	133
7.7	The bottom line	135
	References	135
<b>8</b>	<b>Efferent Copy</b>	<b>139</b>
8.1	Elements of history	139
8.2	Current terminology	140

8.3	Kinesthetic perception	143
8.4	Efferent copy within a general scheme of motor control	149
8.5	The bottom line	154
	References	154
<b>9</b>	<b>Central Pattern Generator</b>	<b>157</b>
9.1	Elements of history	157
9.2	Current terminology	160
9.3	Various CPGs	162
9.4	Cyclic versus discrete actions	168
9.5	The role of CPGs in movements	170
9.6	The bottom line	171
	References	171
<b>Part Three Motor Control Concepts</b>		<b>175</b>
<b>10</b>	<b>Redundancy and Abundance</b>	<b>177</b>
10.1	Elements of history	178
10.2	Current terminology	181
10.3	Optimization	186
10.4	Optimal feedback control	193
10.5	Abundance in movements	195
10.6	Relations to everyday voluntary movements	197
10.7	The bottom line	200
	References	200
<b>11</b>	<b>Motor Synergy</b>	<b>205</b>
11.1	Elements of history	206
11.2	Current terminology	207
11.3	Analysis of Synergy-C	214
11.4	Synergy-C: examples of synergies	221
11.5	Anticipatory synergy adjustments	228
11.6	Atypical synergies	230
11.7	Changes in synergies with practice	232
11.8	Origins of synergies	235
11.9	The bottom line	239
	References	240
<b>12</b>	<b>Equilibrium-Point Hypothesis</b>	<b>247</b>
12.1	Elements of history	247
12.2	Current terminology	251
12.3	Control with threshold elements	253
12.4	Control of a single muscle	255
12.5	Control of a joint	259

12.6	Referent configuration hypothesis	262
12.7	Equifinality and its violations	264
12.8	Relation of the EP hypothesis to the notion of synergies	266
12.9	The bottom line	270
	References	270
<b>13</b>	<b>Motor Program</b>	<b>275</b>
13.1	Elements of history	276
13.2	Current definitions for motor program	278
13.3	What can be encoded by signals from the brain?	282
13.4	Are there motor programs in the spinal cord?	289
13.5	Do neuronal populations in the brain generate motor programs?	290
13.6	Impaired motor programs	293
13.7	Are new motor programs created in the process of motor learning?	295
13.8	The bottom line	297
	References	298
<b>Part Four Examples of Motor Behaviors</b>		<b>303</b>
<b>14</b>	<b>Posture</b>	<b>305</b>
14.1	Elements of history	306
14.2	Creating a definition for posture	307
14.3	Posture as a steady-state process: postural sway	309
14.4	Posture and movement: two outcomes of control with referent configurations	315
14.5	Postural synergies	317
14.6	Postural preparation to action	321
14.7	Posture-stabilizing mechanisms	327
14.8	The bottom line	329
	References	329
<b>15</b>	<b>Grasping</b>	<b>335</b>
15.1	Elements of history	335
15.2	Basic mechanics of grasps	337
15.3	Basics of grasp control	340
15.4	Motor control constraints in hand and digit actions	347
15.5	Prehension synergies	352
15.6	The bottom line	358
	References	360
<b>Glossary</b>		<b>365</b>
<b>Index</b>		<b>401</b>