

# Contents

1	Introduction .....	1
1.1	About the contents of this book .....	2
1.2	Historical remarks.....	7
2	Methods in Trauma-Biomechanics .....	15
2.1	Statistics, field studies, databases .....	15
2.2	Injury criteria, injury scales and injury risk .....	19
2.3	Basic technical definitions and accident reconstruction .....	23
2.4	Experimental models .....	29
2.5	Standardised test procedures .....	34
2.5.1	Anthropomorphic test devices .....	40
2.6	Numerical methods .....	48
2.7	References .....	52
3	Head Injuries .....	55
3.1	Anatomy of the head .....	55
3.2	Injuries and injury mechanisms .....	57
3.3	Mechanical response of the head .....	62
3.4	Injury criteria for head injuries .....	66
3.4.1	Head Injury Criterion (HIC) .....	67
3.4.2	Head Protection Criterion (HPC) .....	68
3.4.3	3 ms criterion ( $a_{3ms}$ ) .....	69
3.4.4	Generalized Acceleration Model for Brain Injury Threshold ...	69
3.5	Head injuries in sports.....	71
3.6	Head injury prevention.....	73
3.6.1	Head injury prevention in pedestrians.....	75
3.7	References .....	78
4	Spinal Injuries .....	83
4.1	Anatomy of the spine .....	84
4.2	Injury mechanisms .....	87

4.3 Biomechanical response and tolerances .....	95
4.4 Injury criteria .....	99
4.4.1 Neck injury criterion NIC .....	100
4.4.2 $N_{ij}$ neck injury criterion .....	101
4.4.3 Neck protection criterion $N_{km}$ .....	103
4.4.4 Intervertebral neck injury criterion (IV-NIC) .....	106
4.4.5 Neck displacement criterion (NDC) .....	106
4.4.6 Lower Neck Load Index (LNL) .....	107
4.4.7 Neck injury criteria in ECE and FMVSS .....	107
4.4.8 Correlating neck injury criteria to the injury risk .....	109
4.5 Spinal injuries in sports.....	111
4.6 Prevention of soft tissue neck injury.....	112
4.6.1 Head restraint geometry and padding material.....	114
4.6.2 Controlling head restraint position.....	115
4.6.3 Controlling seat back motion.....	117
4.7 References .....	119
 5 Thoracic Injuries .....	127
5.1 Anatomy of the thorax .....	127
5.2 Injury mechanisms .....	129
5.2.1 Rib fractures .....	131
5.2.2 Lung injuries .....	132
5.2.3 Injuries to other thoracic organs .....	133
5.3 Biomechanical response .....	135
5.3.1 Frontal loading .....	135
5.3.2 Lateral loading .....	141
5.4 Injury tolerances and criteria .....	143
5.4.1 Acceleration and force .....	143
5.4.2 Thoracic Trauma Index (TTI) .....	143
5.4.3 Compression Criterion (C) .....	144
5.4.4 Viscous Criterion (VC) .....	144
5.4.5 Combined Thoracic Index (CTI) .....	145
5.4.6 Other criteria .....	146
5.5 Thoracic injuries in sports.....	146
5.6 References .....	147
 6 Abdominal Injuries .....	149
6.1 Anatomy of the abdomen .....	149
6.2 Injury mechanisms .....	150
6.3 Testing the biomechanical response .....	153
6.4 Injury tolerance .....	155

6.4.1 Injury criteria .....	156
6.5 Influence of seat belt use .....	157
6.6 Abdominal injuries in sports.....	157
6.7 References .....	158
 7 Injuries of the Pelvis and the Lower Extremities .....	161
7.1 Anatomy of the lower limbs .....	161
7.2 Injury mechanisms .....	163
7.2.1 Injuries of the pelvis and the proximal femur .....	168
7.2.2 Leg, knee and foot injury .....	170
7.3 Impact tolerance of the pelvis and the lower extremities .....	172
7.4 Injury criteria .....	176
7.4.1 Compression force .....	176
7.4.2 Femur Force Criterion (FFC) .....	176
7.4.3 Tibia Index (TI) .....	177
7.4.4 Other criteria .....	177
7.5 Pelvic and lower extremity injuries in sports.....	178
7.6 Prevention of lower extremity injuries .....	181
7.6.1 Pedestrian injury countermeasures.....	182
7.7 References .....	183
 8 Injuries of the Upper Extremities .....	187
8.1 Anatomy of the upper limbs .....	188
8.2 Injury incidences and mechanisms .....	189
8.3 Impact tolerance .....	191
8.4 Injury criteria and evaluation of injury risk from airbags .....	193
8.5 Upper extremity injuries in sports.....	194
8.6 References .....	198
 9 Impairment and injuries resulting from chronic mechanical exposure...	201
9.1 Occupational health.....	204
9.2 Sports.....	206
9.2.1 Non contact sports.....	206
9.2.2 Contact sports.....	208
9.3 Household work.....	208
9.4 Conclusions.....	208
9.5 References.....	209