RELATED WORK IN VALIDATING MUSCULOSKELETAL MODELS

Model	Movements	Validated Body Parts	Type of Data	Drawbacks	Year	Reference
Wrist with 4 virtual muscles	Static poses	4 virtual muscles	Previous EMG	Simplified model, no movement, qualitative comparison to earlier data	1974	[19]
Shoulder with 34 muscles	Arm elevation in sagittal plane	Anterior Deltoid, supraspinatus, infraspinatus	EMG	Specific simplistic movement, only 3 validated muscles	1992	[12]
Upper Limb with 30 muscles	–	–	–	No Validation	1992	[21]
Elbow with 3 flexor muscles	Elbow flexion	Biceps, Brachioradialis, Brachialis	Validated predicted force	Simplified model, specific simplistic movement, only 3 validated muscles, no recorded EMG	1993	[2]
Finite element shoulder	Abductions of shoulder	12 muscles	EMG	Single joint model, specific simplistic movement in 1D	1994	[26]
Shoulder with 1 degree of freedom and two muscles	Goal directed shoulder movements in sagittal plane	Anterior Deltoid and Latissimus Dorsi	Previous EMG	Simplified model with no real muscles, simplistic movements in 1D of single joint, lack of correspondence between model muscles and muscles for which EMG was used	1994	[8]
Index Finger and Thumb	Pinching, hypothetical rotation	Flexors and Extensors of Fingers	Previous EMG	Different model and type of movements	1995	[1]
Shoulder with 20 muscles	Aimed movement in sagittal plane	9 shoulder muscles	EMG timing	Single joint, simplistic movements, qualitative EMG timing comparison	1995	[9]
Shoulder with 30 muscles	Static posture	9 muscles	EMG	Single joint, static posture	1995	[17]
Shoulder with 30 muscles	Aimed movements in frontal plane	7 muscles	EMG	Single joint, small set of different movements	1995	[16]
Elbow joint with flexor and extensor muscles	–	–	–	No Validation	1996	[22]
Elbow with 8 muscles	Ballistic movements	8 muscles	EMG	Single joint, specific movements	1996	[5]
Shoulder with 30 muscles for load-sharing	–	–	–	No Validation	1996	[15]
Elbow with 3 flexors	Elbow flexions with different speed	Biceps, brachialis and brachioradialis	Previous EMG	Simplified model, specific simplistic movements, no own EMG	1997	[3]
Elbow with 8 muscles	Elbow flexion and supination	8 elbow muscle	EMG	Single joint, specific movements, qualitative comparison	1998	[6]
Upper Limb with 21 muscle	Static pull	21 muscle of upper limb	Sum of forces	Static posture, no EMG	1999	[11]
Shoulder and elbow with 2 degrees of freedom and 6 muscles	–	–	–	No Validation	2000	[25]

Elbow with 2 muscles	Elbow flexion	Flexor and extensor	EMG	Simplified model, single joint, specific movement	2000	[13]
Elbow with 5 muscles	–	–	–	No Validation	2003	[23]
Shoulder and elbow with 6 virtual muscles	Constrained rotations	Posterior deltoid, pectoralis major, tricepls lateral head, brachialis, long head of triceps, biceps	EMG	Simplified model, specific movements, lack of correspondence between model muscles and muscles with EMG	2004	[18]
Shoulder with 13 muscles	Wheelchair propulsion	13 shoulder muscles	Previous forces	Single joint, specific movement, no own groundtruth	2004	[14]
Upper Extremity	Different static postures of the arm	Shoulder, elbow and wrist	Joint Moments	Static postures, no muscle validation	2005	[10]
Elbow with 6 muscles	–	–	–	No Validation	2005	[20]
Delft Shoulder and Elbow with 31 muscle	–	–	–	No Validation	2005	[27]
Elbow with 5 muscles	Elbow flexions in horizontal plane	Biceps, triceps	EMG	Single joint, specific movements, only 2 muscles with EMG	2005	[24]
Modified Upper Extremity	Specific reaching movement to single point in front	Anterior Deltoid, Biceps, Triceps	EMG	Specific movement, only 3 muscles, qualitative comparison, lack of agreement between predicted activations and EMG	2009	[4]
Lower Extremity	Running	8 Lower Extremity muscles	EMG, Previous EMG	Completely different part of body	2010	[7]
Upper Extremity	Full-arm pointing in all directions and locations	8 Upper Extremity muscles	EMG, Previous EMG	–	–	This paper

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