APPENDIX B

UNITS AND DEFINITIONS RELATED TO BIOMECHANICAL AND ELECTROMYOGRAPHICAL MEASUREMENTS

All units used are SI (Système International d'Unités). The system is based on seven well-defined base units and two supplementary units. Only one measurement unit is needed for any physical quantity, whether the quantity is a base unit or a derived unit (which is the product and/or quotient of two or more of the base units).

TABLE B.1 Base SI Units

Physical Quantity	Symbol	Name of SI Unit	Symbol of Unit
Length	l	meter	m
Mass	m	kilogram	kg
Time	t	second	s
Electric current	I	ampere	A
Temperature	T	kelvin	K
Amount of substance	n	mole	mol
Luminous intensity	I	candela	cd
Plane angle	θ, ϕ, etc.	radian	rad
Solid angle	Ω	steradian	sr

TABLE B.2 Derived SI Units

Physical Quantity	Symbol	Name of SI Unit	Definition
Velocity	v	$m \cdot s^{-1}$	Time rate of change of position.
Acceleration	a	$m \cdot s^{-2}$	Time rate of change of velocity.

(continued)

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TABLE B.2 ***(Continued)***

Physical Quantity	Symbol	Name of SI Unit	Definition
Acceleration	g	$m \cdot s^{-2}$	Acceleration of a freely falling body in a vacuum because of gravity. At sea level $g = 9.80665\,m \cdot s^{-2}$.
Angular velocity	$\boldsymbol{\omega}$	$rad \cdot s^{-1}$	Time rate of change of orientation of a line segment in a plane.
Angular acceleration	$\boldsymbol{\alpha}$	$rad \cdot s^{-2}$	Time rate of change of angular velocity.
Angular displacement	$\boldsymbol{\theta}$	radian (rad)	Change in orientation of a line segment, which is given by the plane angle between initial and final orientations.
Period	T	second (s)	Time to complete one cycle of a periodic event or, more generally, time duration of any event or phase of an event.
Frequency	f	hertz (Hz)	Number of repetitions of a periodic event that occurs in a given time interval. 1 Hz equals 1 repetition or cycle per second. ($1\,Hz = 1\ s^{-1}$)
Density	$\boldsymbol{\rho}$	$kg \cdot m^{-3}$	Mass per unit volume of an object or substance.
Specific gravity	d		Ratio of the density of a substance to the density of water at 4°C.
Force	F	newton (N)	Effect of one body on another that causes the bodies to accelerate relative to an inertial reference frame. 1 N is that force that, when applied to 1 kg of mass, causes it to accelerate at $1\,m \cdot s^{-2}$in the direction of the force application relative to the inertial reference frame. ($1\,N = 1\,kg \cdot m \cdot s^{-2}$.)
Weight	G	N	Force exerted on a mass because of gravitational attraction; equal to the product of the mass of the body and the acceleration from gravity. ($G = m \cdot g$.)

TABLE B.2 ***(Continued)***

Physical Quantity	Symbol	Name of SI Unit	Definition
Mass moment of inertia	I	$kg \cdot m^2$	Measure of a body's resistance to accelerated angular motion about a given axis; equal to the sum of the products of the masses of its differential elements and the squares of their individual distances from that axis.
Linear momentum	p	$kg \cdot m \cdot s^{-1}$	Vector quantity possessed by a moving rigid body, quantified by the product of its mass and the velocity of its mass center.
Angular momentum	L	$kg \cdot m^2 \cdot s^{-1}$	Vector of the linear momentum of a rigid body about a point; the product of the linear momentum and the perpendicular distance of the linear momentum from the point. For planar movement, the angular momentum is the product of the moment of inertia in the plane about its centroid and the angular velocity in the plane.
Moment of force	M	$N \cdot m$	Turning effect of a force about a point; the product of the force and the perpendicular distance from its line of action to that point.
Pressure, normal stress, shear stress	p	pascal (Pa)	Intensity of a force applied to, or distributed over, a surface; the force per unit area. 1 Pa is the pressure resulting from 1 N applied uniformly and in a directional perpendicular over an area of 1 m^2. ($1\ Pa = 1\ N \cdot m^{-2}$.)
Linear strain Shear strain	ε γ		Deformation resulting from stress measured by the percentage change in length of a line (linear strain) or the change in angle of an initially perpendicular line (shear strain).

(continued)

TABLE B.2 ***(Continued)***

Physical Quantity	Symbol	Name of SI Unit	Definition
Young's modulus Shear modulus	E G	Pa	Ratio of stress to strain over the initial linear portion of a stress–strain curve.
Work	W	joule (J)	Energy change over a period of time as a result of a force acting through a displacement in the direction of the force. 1 J is the work done when a force of 1 N is displaced a distance of 1 m in the direction of the force ($1\,\text{J} = 1\,\text{N} \cdot \text{m}$.). Work is also the time integral of power. ($1\,\text{J} = 1\,\text{W} \cdot \text{s}$.).
Mechanical energy	E	J	Capacity of a rigid body to do work; quantified by the sum of its potential and kinetic energies.
Potential energy	V	J	Energy of a mass or spring associated with its position or configuration relative to a spatial reference. Gravitational potential energy of a mass m raised a distance h above the reference level equals mgh, where g is the acceleration from gravity. Elastic potential energy of a linear spring with stiffness k stretched or compressed a distance e equals $k \cdot e^2/2$.
Kinetic energy	T	J	Energy of a mass associated with its translational and rotational velocities. The translational kinetic energy T of a mass m with a velocity v is $1/2\ mv^2$. The rotational kinetic energy T of a body rotating in a plane with a moment of inertia I rotating with a angular velocity $\boldsymbol{\omega}$ is $1/2\ I\boldsymbol{\omega}^2$.

TABLE B.2 ***(Continued)***

Physical Quantity	Symbol	Name of SI Unit	Definition
Power	P	watt (W)	Rate at which work is done or energy is expended. The power generated by a force is the dot product of the force and the velocity at the point of application of the force ($P = F \cdot V$). The power generated by a moment is the dot product of the moment and the angular velocity of the rigid body ($P = M \cdot \boldsymbol{\omega}$).
Coefficient of friction	$\boldsymbol{\mu}$	—	For two objects in contact over a surface, the ratio of the contact force parallel to the surface to the contact force perpendicular to the surface.
Coefficient of viscosity	$\boldsymbol{\eta}$	$N \cdot s \cdot m^{-2}$	Resistance of a substance to change in form; calculated by the ratio of shear stress to its rate of deformation.
Electrical charge	q	coulomb (C)	Quantity of a negative or positive charge on any mass. The charge on an electron or proton is 1.602×10^{-19}C, or 1·C, has the charge of 6.242×10^{18}electrons or protons [1 A (ampere) $= 1\,C \cdot s^{-1}$].
Voltage, electrical potential	E	volt (V)	Potential for an electrical charge to do work ($1\ V = 1\,J \cdot C^{-1}$).
Electrical resistance	R	ohm ($\boldsymbol{\Omega}$)	Property of a conducting element that opposes the flow of electrical charge in response to an applied voltage ($1\ \boldsymbol{\Omega} = 1\ V \cdot A^{-1}$).
Electrical capacitance	C	farad (F)	Property of an electrical element that quantifies its ability to store electrical charge. A capacitance of 1 F means that 1 C of charge is stored with a voltage change of 1 V ($1\ F = 1\,C \cdot V^{-1}$).

NOTES TO TABLES B.1 AND B.2

1. Prefixes are used to designate multiples or submultiples of units.

Prefix	Multiplier	Symbol	Examples
mega	10^6	M	megahertz (MHz)
kilo	10^3	k	kilowatt (kW)
centi	10^{-2}	c	centimeter (cm)
milli	10^{-3}	m	millisecond (ms)
micro	10^{-6}	μ	microvolt (μV)

2. (a) When a compound unit is formed by multiplication of two or more units, the symbol for the compound unit can be indicated as follows:

$$\text{N} \cdot \text{m or N m, but not Nm}$$

(b) When a compound unit is formed by dividing one unit by another, the symbol for the compound unit can be indicated as follows:

$$\text{kg/m}^3 \text{ or as a product of kg and } \text{m}^{-3}, \text{ kg} \cdot \text{m}^{-3}$$

3. Because the symbol for second is s, not sec, the pluralization of symbols should not be done; for example, kgs may be mistaken for kg · s, or cms may be mistaken for cm · s.