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Physiology of Distinct Modes of Muscular Contraction

Nasim Habibzadeh[1,*]

[1]PhD in Sport Science, Teesside University, UK

Abstract

Physiological changes in musculature allow widespread movements in human body. Correspondingly, varying in muscle prototypes characterise direct different training paradigms in therapeutics practice or can governs athletic performances. Mode of muscle contraction type are isometric, concentric or eccentric. Great examples of concentric exercise are walking- up-hill, stair ascent and lifting a dumbbell in bicep curl or pushing a bar up. Examples of eccentric muscle actions are walking - down-hill, satire decent and, isokinetic arm and leg extensions. During isometric muscle contraction the length of muscle does not change while muscle exert force .This type of movement can be seen while a person performs a maximal voluntary contractions (MVCs).Eccentric exercises increasing the concentric and isometric contraction as well. Performing the eccentric muscle contraction in daily life enhance quality of life and lifespan due to increasing muscle strength with low cost of energy consuming and thus it can apply in variety of domains. A simple walking task such as downhill - walking (i.e. 30 min) can provide the aforementioned conditions.

Corresponding author: Nasim Habibzadeh, PhD in Sport Science, Teesside University, UK, Email: Nasimhabibzadeh@yahoo.com

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Introduction

Investigations of the skeletal muscle structure and function refer to the the Renaissance period in the history[1]. This early observation has become the foundations of the physiology and clinical approaches in modern era[2].

Virtually, all movements including any obvious or subtle movements result from muscle contractions. The integrations of the skeletal – muscle and associated joints fulfil large motions such as in walking and running while move body around delicately in different position or posture[3]. Dynamic skeletal muscle plasticity allows widespread movements in human body[4].

Untypical muscles have ability to uniquely contract, lengthen or shorten to generate motions. Nonetheless, muscle types differ in functional structure and capability, so that various muscles executed deliver different movement loads depending on the features and characteristics[5,6]. Correspondingly, varying in muscle prototypes characterise the physical strength physiology in human body. Physiological changes in musculature strength can influence the movement performances in different areas. Skeletal muscle in fact is a regulatory property of exercise regimes in different areas.

Diverse properties of human skeletal muscle can direct different training paradigms in therapeutics practice or can governs athletic performances. In this relation, it is shown that eccentric muscle contraction enhance muscle strength and in part increase the concentric and isometric strength. This is because eccentric contraction maintain or increase muscle mass and bone mass density more than other types of contraction types. The physiological role of contraction types regulate the efficacy of muscle activation types[7]. Thus, further studies on muscle contractions can provide more feature of muscle ability and the movement efficiency, which it produces in sport and medicine setting.

Physiological Responses of Musculoskeletal System to Exercise Mechanical Load

One characteristics of human skeletal muscle is the ability to adapt to widespread physiological stimuli such as those produces by variety of exercise paradigm. The complex process by which muscle influenced by mechanical load involved an interrelated pathway in a network of musculoskeletal system[8]. Under exercise stimulation four physiological stressors of mechanical load, neuronal activation, hormonal adjustments and metabolic disturbances simultaneously work to induce histological changes in contractile activities of skeletal muscle plasticity.[9]

Mechanical load is a complex parameter that is recorded by various type of receptors in varying exercise -tasks. Feedback from mechanical load is driven from many specific and non-specific load receptors in central nervous system. For example, when lower-limbs are loaded during stance phase in walking gait cycle, plenty of receptors such as cutaneous receptor from feet, spindle from stretched legs and trunk muscles are activated to stimulate the extensor part of body and to suppress the flexion at the same time to modulate the rhythm of locomotion. Resultantly, mechanical load play an important role in shaping movement locomotor pattern from motor output by switching the extensor or flexor muscle activations bursts in a functionally relevant manner[10,11].

Alternatively, applied stretch in stance phase activates both afferent signals from spindle receptors (group Ia afferents) to regulate muscle length and velocity to alter mechanical response and Golgi tendon organs (GTO) (group Ib afferents) to adjust proper force. Further, a more selective afferent ∑ signal is stimulated to strength force of the load. In addition, neural signals are sent to the other skeletomotor and fusimotor neurons in the central network to transmit impulses in the central pathways. Contribution of these signals obtain the excitatory or inhibitory feedbacks to control phase – transition and ongoing motions during various locomotor tasks[12,13] (Figure 1).

Correspondingly, hormonal responses (e.g., adrenaline, noradrenalin, glucagon, insulin, and cortisol) increase to optimize the functional adaptions of the skeletal muscle to the exercise loading to produce sufficient[14,15]. This is followed by, the sense of information which organize the appropriate responses to the proper organs or tissue regions. At a subsequent time, the systemic hormones change the activation of tissue that possess the receptor at which the hormone can bind[16]. Increased hormonal responses

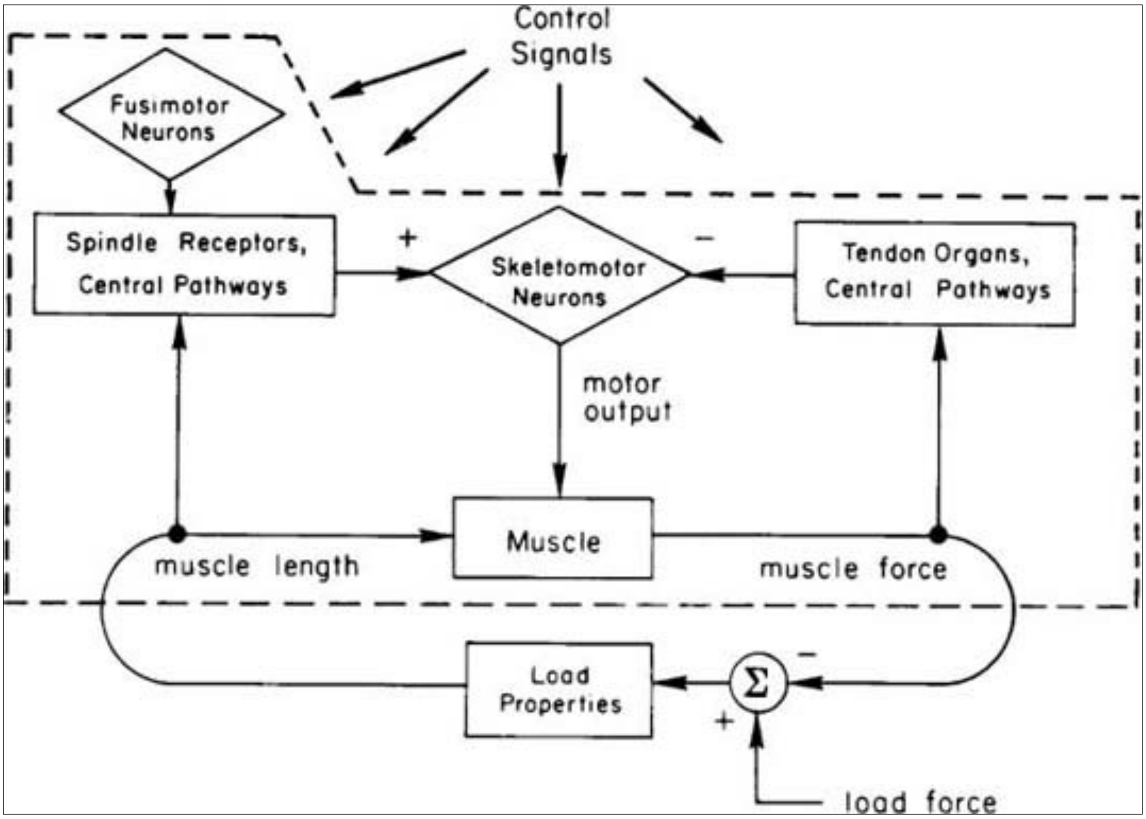

Figure 1. Physiological properties of muscle – tendon responses to onset of exercise mechanical load [12]

induced-exercise in circulation enhance the energy turnover made by contracting skeletal muscle and other surrounding tissues to load demand during given mechanical tasks[17].

Irrespective of the mode of exercise, either isometric, concentric or eccentric muscle activity, the skeletal muscle plasticity allow to meet the metabolic potential demands to the exercise mechanic[18]. Exercise - tasks in fact, is represented by a potential disruption of homeostasis to the internal and external stimuli of distinct modalities to optimize the functional performances. In principal, such metabolic adjustments can be coordinated by some regulatory mechanisms in metabolic fuels in response to the exercise load[19]. Under this condition, based on metabolic adaption, provision of the rate of adenosine triphosphate (ATP) demand, energy expenditures and contribution of the endogenous carbohydrate (CHO) and lipids are regulated through various types of metabolic pathways in skeletal muscle in response to the different forms of exercise load mechanic[20].

Comparative Aspects of Distinctive Skeletal Muscle Contractions

Literally, skeletal muscle are main executor of any mechanical functions at which can generate maximum contractile force respectively about 3- 4 Kilogram per square centimetre (kg/cm^2) of cross sectional area depending on the contraction types[21].

The skeletal – muscle systems produce two of quasi-isometric and isotonic muscular contractions[22,23,24]. Isometric muscle contraction includes all type of the static actions and the isotonic contraction involve the dynamic contractions that comprises all eccentric and concentric muscle actions[25,26,27]. Evidently, non-identical types of muscle contraction produce different motion mechanics with the subsequent unique mechanical force in nature[28,29].

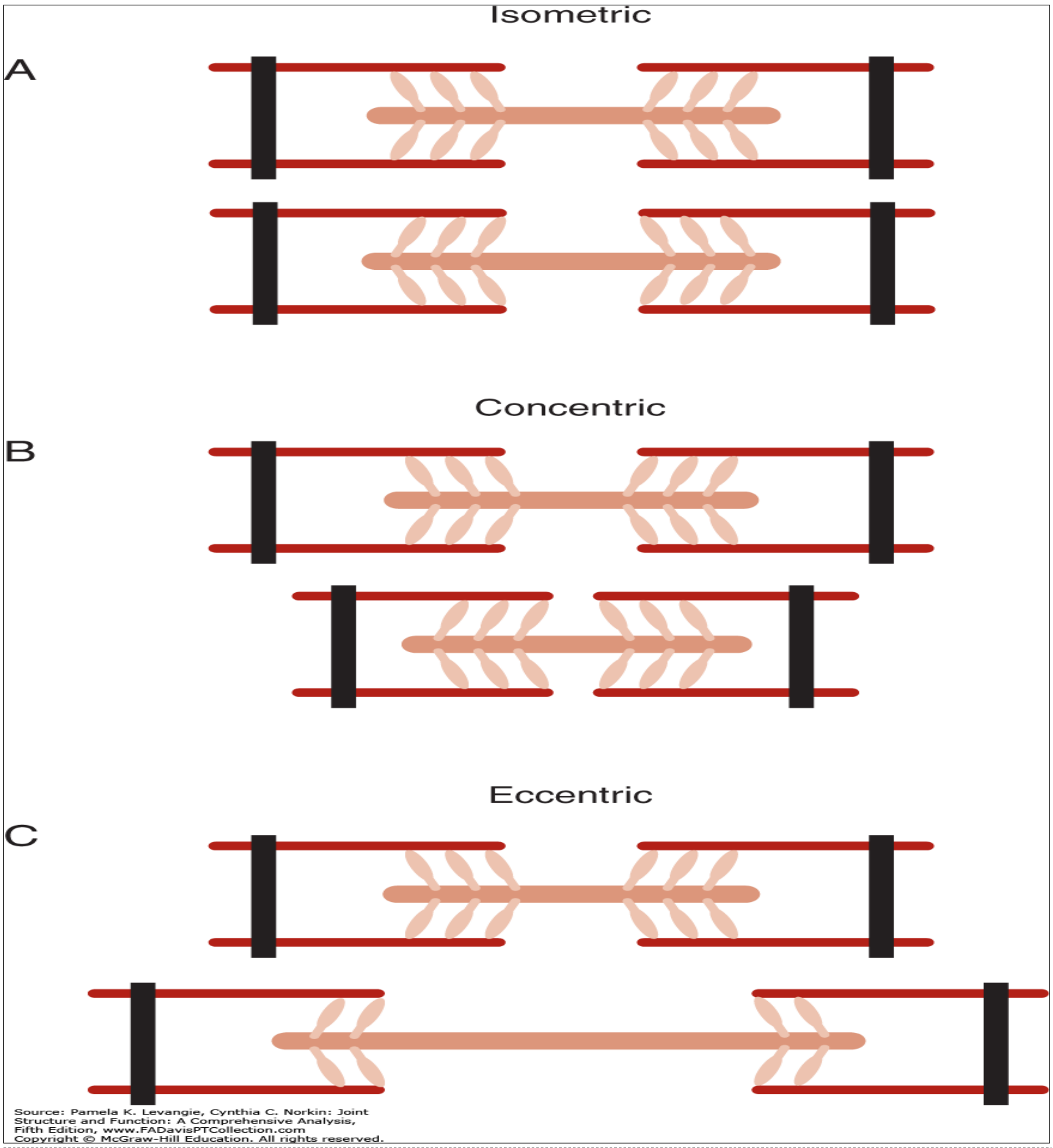

Figure 2. Prospective of dissimilar muscle contractions

Quasi-isometric contraction is that type of contraction that tensing the muscle to produce force without creating any visible movement from distance between muscle origin and insertion although the tensions develop to slides the filaments[30,31]. Resultantly, there is no apparent alterations in joint angle, range of motion and muscle length while tensions progress during isomeric contraction (Figure 2 A). Nevertheless, in spite of no changes in muscle length in isometric contraction, still it importantly attribute in body actions such as maintaining subtle body frame in an equal dimension to counterbalance gravity[32,33].

During isotonic contraction muscle changes in length, angle and range of motion, with sliding myofilaments occurrences that provoke muscle movement from the end of insertion point to which relative origin point while producing force[34]. Isotonic contraction compose of two concentric and eccentric dynamic contractions that are executed at constant mechanical loads without any speed limits but in different orientation (Figure B &Figure 2C). Isotonic concentric and eccentric contractions move body parts differently to lead various dynamic motions in practice[35,36]. Subsequently, relevant positions during each dynamic contraction types differentiate produced mechanical force and maximal individual strength potentiality in broad ranges of ordinary physical tasks or sport activities[37,38,39].

Patterns of Distinct Eccentric and Concentric Muscle Contractions

Great examples of concentric exercise are walking- up-hill, stair ascent in weight – bearing terms. Lifting a dumbbell in bicep curl or pushing a bar up that mechanically in resistance training at required level of time (Figure 3).

Examples of eccentric dominant muscle actions are walking - down-hill, satire decent in weight- bearing kind of exercises. In addition, isokinetic arm and leg extensions are more patterns of resistance eccentric exercises (Figure 4).

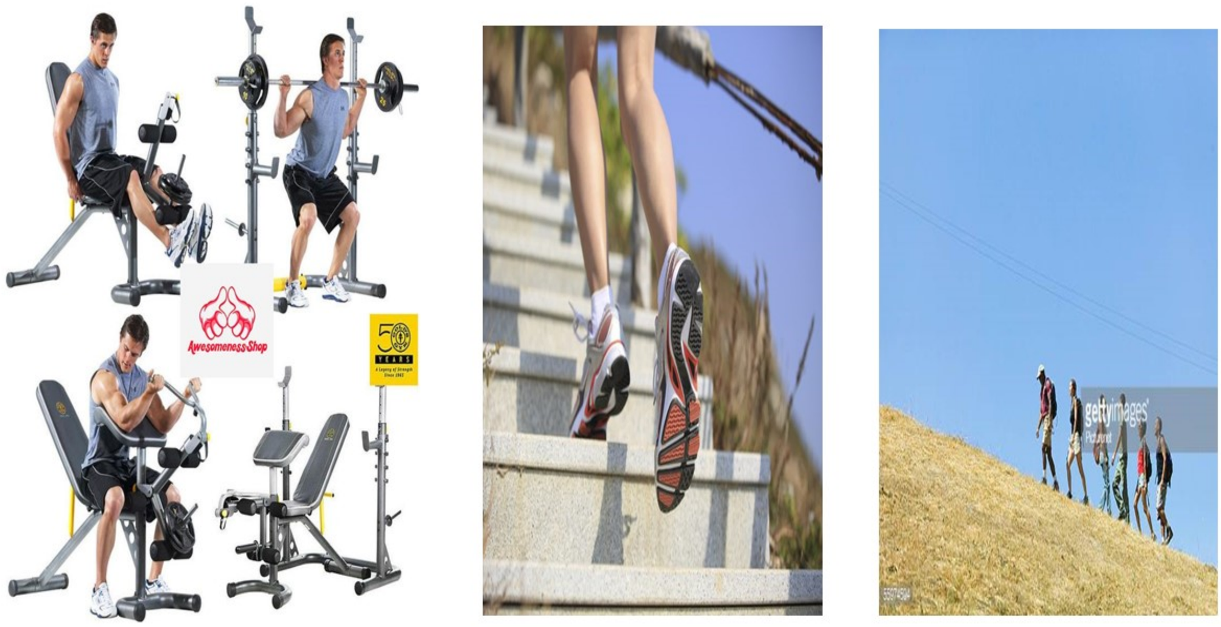

Figure 3. Patterns of dominant concentric contraction themes

Figure 4. Movement patterns of dominant eccentric contraction themes

Summary

All types of muscle contractions play different role in human body. Given the nature of each muscle contraction they are differ in the contraction efficiency to promote health. Contraction types remarkably natural movements and locomotion. Eccentric muscle contraction types due to increasing of muscle strength apply in physical medical condition such as in musculoskeletal rehabilitation programs, and athletic training paradigms. Eccentric training prevent musculoskeletal injury and reduce the risk of falling. Concentric muscle contraction because of consuming a high level of amount of oxygen uptake in comparison with eccentric contraction use in weight loss program .Evidence has shown that eccentric exercise modes has increased both concentric and isometric contraction also . Therefore, performing kind of eccentric contraction types such as walking at downhill in daily task can boost widespread quality of life and well-being.

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