REVIEW ARTICLE

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Measurement Tools Used in the Study of Eccentric Contraction–Induced Injury

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Abstract

The objective of this review is to evaluate the measurement tools currently used in the study of eccentric contraction–induced muscle injury, with emphasis on their usefulness for quantifying the magnitude and duration of the injury and as indicators of muscle functional deficits. In studies in humans, it was concluded that measurements of maximal voluntary contraction torque and range of motion provide the best methods for quantifying muscle injury. Similarly, in animal studies, the *in vitro* measurement of electrically elicited force under isometric conditions was considered to be the best of the measurement tools currently in use.

For future studies, more effort should be put into measuring other contractile parameters (e.g. force/torque-velocity and force/torque-length relationships, maximal shortening velocity and fatigue susceptibility) that may reflect injury-induced functional impairments. The use of histology, ratings of soreness and the

measurement of blood or bath levels of myofibre proteins should be discouraged for purposes of quantifying muscle injury and/or functional impairment.

There has been considerable interest in the medical literature regarding the phenomenon of eccentric contraction–induced skeletal muscle injury, particularly over the past 15 years. Numerous studies have been published describing the injury, investigating mechanisms underlying the pathology and seeking preventative and therapeutic interventions. As with any clinical or scientific problem, it is important to develop 'markers' or measures that permit precise quantification of the phenomenon. However, even a cursory perusal of the literature demonstrates that a wide variety of criteria for muscle injury has been employed, and that there has been no general agreement on the best methods for quantifying the pathology. This article aims to evaluate the various markers for eccentric contraction–induced muscle injury and presents our recommendations on the most useful methods for quantifying this form of muscle injury.

From both basic and clinical science perspectives, injury criteria should relate to muscle function. The clinical importance of considering the functional manifestations of the injury has been emphasised by recent legislation in the US included in the Omnibus Budget Reconciliation Acts of 1989 and 1990 (PL 101-239 and 101-508). The earlier act created the Agency for Health Care Policy and Research (AHCPR), which has responsibility for the study of outcomes and effectiveness of diagnostic, therapeutic and preventative health care services and procedures. A year later, a comprehensive study of rehabilitation financing was mandated and the National Center for Medical Rehabilitation Research (NCMRR) was created under the National Institutes of Health (NIH). Both acts have resulted in a move in rehabilitation healthcare towards 'functional outcomes management', with an emphasis on the development of functional measurement tools.[1-3] Because of this emphasis, and the fact that work- and exercise-induced muscle injury have medical significance,[4,5] the functional criteria used in evaluation of muscle injury warrant critical review as a healthcare issue.

Basic science has been affected by this legislation as well. In 1994, NIH/NCMRR and AHCPR co-sponsored a conference, 'An Agenda for Medical Rehabilitation Outcomes Research', at which the improvement of functional measurement tools and encouragement of uniformity in the use of these tools across all specialties was called for.[6] The guidelines formalised at this conference, in addition to others, will most likely dictate the direction of future basic biomedical science research in the US.

Thus, in this article, we take the view that measures of muscle function provide the best means for evaluating the magnitude and time-course of muscle injuries resulting from eccentric contractions. Muscle function is operationally defined as the ability to exert force under a given set of conditions, that is, over a given range of motion (ROM) or at a fixed muscle length, at a given velocity or at a given external load, at a given level of activation and over a given number of contractions. A tool that assesses 1 or more of these components of muscle function is defined as a functional measurement tool. From a functional standpoint, muscle injury may be defined as a prolonged (i.e. lasting days or weeks) impairment of the ability of a muscle to produce force.

After describing methods for evaluating muscle function in injured muscles, this article compares other measurement tools that have been used. (We reviewed only those studies in which the injury was induced by the performance of eccentric contractions or exercise biased towards eccentric contractions.) The article has been divided into an evaluation of those measurement tools used in human studies and those used in animal studies: 52 human studies conducted over the last 15 years and 46 animal studies over the last 13 years were reviewed. This selection of the literature, representative of this research field, was not intended to