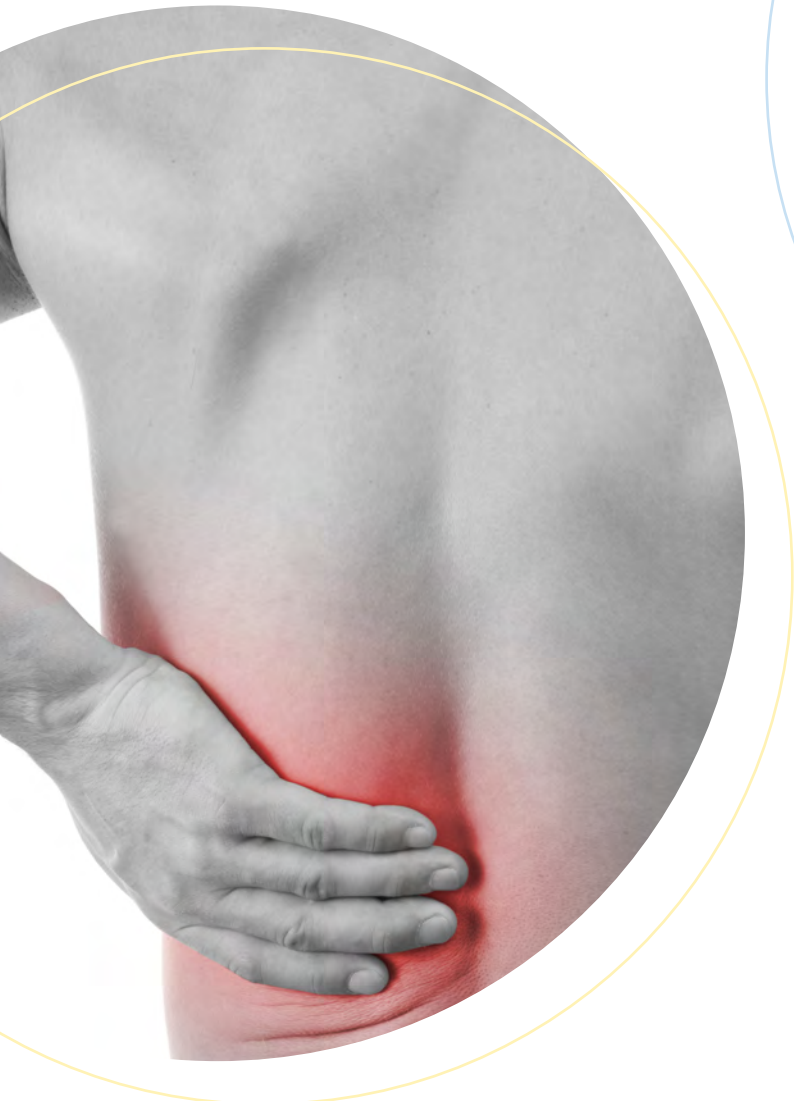

# **Expertise** in motion

# **Musculoskeletal disorders** in the working population

Vern Putz Anderson from the National Institute for Occupational Safety and Health at the Centers for Disease Control and Prevention (CDC) details the risk factors, symptoms and prevention of musculoskeletal disorders in the workplace…

Aches and pains are a part of life, but musculoskeletal disorders, or MSDs, such as back problems, carpal tunnel syndrome, or tendinitis become a problem when you can no longer recover – and in some cases, no longer work. Workers who perform the same tasks repeatedly, work in awkward positions such as stooping or bending, or exert a lot of effort to complete a task, risk injuring muscles, tendons, nerves, joints, ligaments and other soft tissues. These injuries can cause pain and may ultimately impair your ability to work.

MSDs can take a toll on workers, employers, and society. In the United States for example, MSDs accounted for approximately 30% of occupational injuries that resulted in time away from work in 2013 [1]. These injuries also represent one of the top 3 conditions accounting for the greatest number of "years lived with disability" in the U.S. working population [2].

Overexertion, which occurs when you do more lifting, pulling, pushing, or throwing than your body can handle, is one of the most frequent, costly, and disabling workplace injuries. Overexertion accounts for 25% of annual workplace injuries at an annual cost of $15.1bn [3]. In a work setting, overexertion can happen when employees don't have control over the demands of their job – their work may be paced by machines or customers. Additionally, as workers age, the demands of their job might remain constant, yet their endurance has decreased, and the time they need to recover has increased. In these situations the physical demands of the job exceed the worker's capabilities and can lead to discomfort, chronic pain, or disabling injuries.

Most workers recognise the signs and symptoms of overexertion within a few days – if not immediately. Common symptoms include pain, swelling, and restricted movement. It's important not to ignore the first signs of work-related discomfort because it can lead to a more severe, chronic condition. At the onset of symptoms, workers should alert their employer to identify and assess problems with their job before it leads to an MSD [4]. This early warning can indicate the worker is not well-matched to the demands of the job. Early recognition and intervention remain key for preventing long-term injuries and costly workers' compensation payments.

When faced with prospective hazards, the ultimate goal is to design the work area to eliminate the hazard by changing the workplace, job task, and/or tools. Although MSDs affect workers across a range of industries and occupations, an example of the positive impact of this practice comes from the healthcare industry. According to the US Bureau of Labor Statistics, more than half of all MSDs that occur in the healthcare industry involved patient handling and accounted for 14% of all MSDs that resulted in at least one lost day from work in 2010 [5]. The single greatest risk factor for overexertion injuries in healthcare workers is the manual lifting, moving, and repositioning of patients – known as manual patient handling.

Evidence-based research has shown that replacing manual patient handling with safer methods guided by the principles of ergonomics, called safe-patient handling, can significantly reduce overexertion injuries to caregivers. The goal of ergonomics is to reduce stress and eliminate injuries and disorders associated with the overuse of muscles, bad posture, and repeated tasks. In the case of patient handling, it involves the use of mechanical equipment and safety procedures to lift and move patients so that healthcare workers can avoid using manual exertions and reduce their risk of injury.

Prior to the introduction of ergonomic principles, employers relied on their workers to meet production and output demands. In short: workers serviced the machines, rather than machines fitting the needs of workers. Today, ergonomic solutions using mechanical equipment that enhances a worker's ability to do a job safely, also called engineering controls, have been developed for a wide variety of occupations and workers including nurses, carpenters, miners, manufacturers, and transportation and retail workers [6-9].

Effective ergonomic solutions in the workplace, like safe patient handling, can lower the incidence and severity of musculoskeletal injuries, which in turn can improve productivity and lower an employer's costs. The National Institute for Occupational Safety and Health (NIOSH), which is part of the US Centers for Disease Control and Prevention, is a leading source on workplace-related musculoskeletal disorders, their causes, as well as prevention and controls. For more information, visit www.cdc.gov/niosh/topics/ergonomics/ .

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of NIOSH.


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**Vern Putz Anderson, PhD, CPE**
**National Institute for Occupational Safety and Health Centers for Disease Control and Prevention**
**www.cdc.gov/niosh**

# Strengthening weak muscle

Who has not experienced muscle weakness after a few days in bed due to illness or injury? A report by Professor Martin Flück from the Balgrist University Hospital inquires on the underlying mechanism of inactivity-induced muscle degeneration. Possible remedies that halt the consequent replacement of muscle with fat tissue with prolonged disuse are discussed.

€500bn are spent per annum in the European Union for days of hospitalisation due to muscle weakness. There is considerable socio-economic potential in the undertaking to empower the musculoskeletal system in affected patients as this reduces costs of care.

The root of physical weakness lies in a critical reduction of skeletal muscle's force producing capacity due to a loss in muscle mass (called atrophy) in conjunction with a deficient neuromuscular activation or a disruption of the functional chain between muscle and bony articulations (or joints) with injury. This develops a pronounced negative impact on mobility and quality of life. Active measures that counter the biological problem are required to allow the affected individuals to exit from their dependence on welfare. In cases of a plain musculoskeletal pathology or injury, orthopaedic surgery readily re-establishes the basic biomechanical aspects of motor function. Subsequent rehabilitation takes care to reset the muscle's functional capacity. However, compared to the maximal effects seen with training of athletes, measures against muscle wasting in patients appear suboptimal. The applied stimulus is often insufficient in magnitude and/or volume and is modulated by individual factors such as constitution and compliance.

In order to tackle muscle loss effectively it is vital to specifically target the mechanisms controlling the build-up (anabolism) and breakdown (catabolism) of muscle matter. In this regard it is important to consider that skeletal muscle is composed of parallel-aligned fibre cells which demonstrate a natural turnover in the order of 0.6% per day (Fig. 1). Mainly this involves the build-up and breakdown of

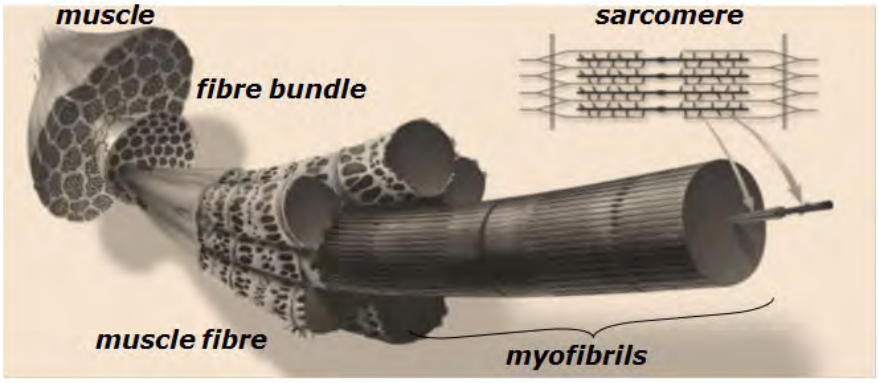



**Figure 1: Illustration of the cellular organisation of skeletal muscle.**
*Adapted from Scientific American.*

myofibrils that hold the molecular motors, the sarcomeres, which carry out contractile function. Mechanical loading is a major anabolic stimulus for muscle, enhancing myofibrillar protein synthesis to an amount equalling 1% of the total content in myofibrils (Fig. 2). The impact of loading on muscle mass is amply illustrated in situations when muscle loading is reduced due to bedrest, inactivity and spaceflight (Fig. 3). The resulting disuse gives rise to a net decrease in muscle mass, force and power as the latter relies on the cross sectional area, and length, of contracting muscle tissue.

Correspondingly, resistance type training produces an increase in muscle force and power and this usually involves a gain in mass of the trained muscle groups. Thereby, the observed muscle plasticity is graded to the time muscle is under tension with contraction. Tension builds up internally in muscle fibres with muscle contraction, and externally via the pulling of attached articulations. Today, mechano-regulation of muscle plasticity is well accepted. It is therefore largely insufficient that the conditioning of muscle's functional capabilities by use-dependent stimuli is, with the exception of rehabilitation, rarely actively targeted, or maximised, in the many situations of muscle weakness.

Forward to this point, our research explores the molecular events underlying muscle atrophy and tests the effectiveness of pharmacological and mechanical measures to counteract muscle wasting. Using this approach we demonstrated that mechanical factors and gene-pharmacological interventions importantly interact regarding the regulation of muscle mass. We also pointed out that an important down-regulation of mechano-sensory processes becomes manifest in anti-gravity muscles after 3 days after unloading. This has important implications for the therapeutic window when a treatment can, and should be applied. This important interdependence of regulation indicates that a pharmacological approach alone, is probably not efficient to halt and reverse muscle atrophy. However, a multidisciplinary approach does not yet appear to be part of the portfolio of major stakeholders, such as the biomedical research industry, despite their recent strategic investments in research aimed at tackling muscle atrophy.

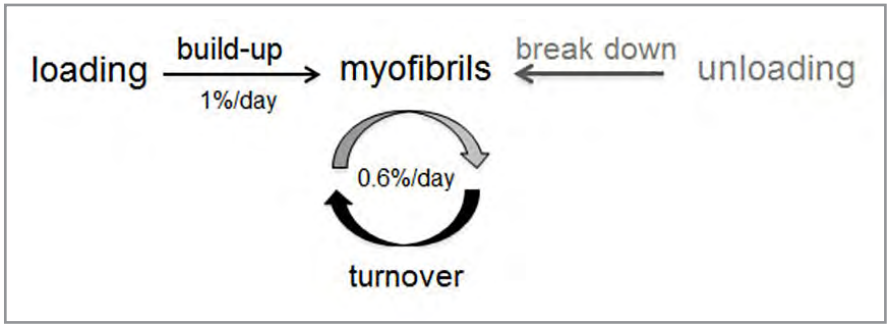



**Figure 2: Concept of the load-dependent regulation of myofibrillar protein turnover.**

Towards this end we test the effectiveness of exercise treatments and exposing factors that dictate

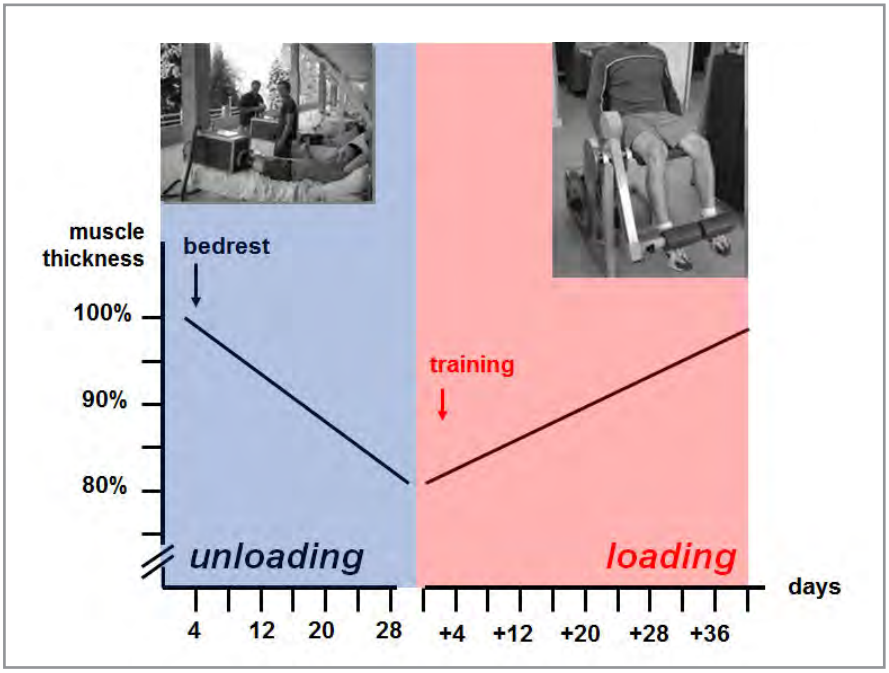



**Figure 3: Mechanical loading regulates muscle mass. Illustration of the reduction in muscle thickness through the time course of unloading due to bedrest and reversion with subsequent strength training.** *Figure assembled from Narici, Seynnes, Flueck et al. (2011), ECSS conference Liverpool (UK) & Vandenborne et al. (1998), Muscle Nerve 21 (8): 1006-12.*

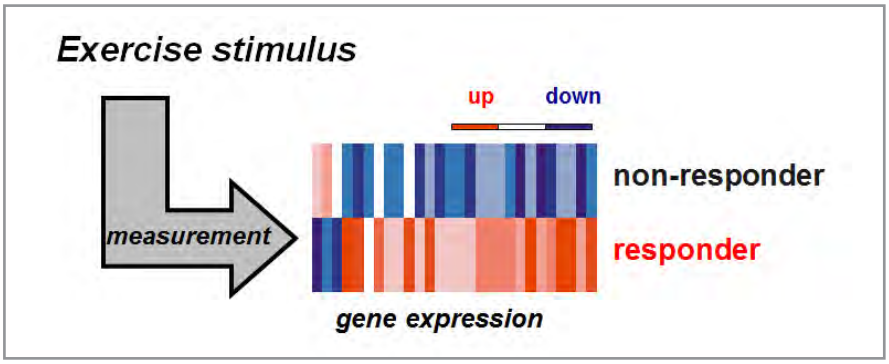



**Figure 4: Genome encoded program fortells muscle response. Composite figure illustrating the response pattern of gene expression for a set of markers to an exercise stimulus for two groups of subjects. The two groups differ regarding their responders due to the presence or absence of a gene polymorphism in the gene for angiotensin converting enzyme.**
*Assembled from Vaughan et al. (2013) Eur J Appl Physiol 113 (7): 1719-1729.*

the individual training response of muscle mass and function in subjects. Our molecular-biological studies highlight that muscle adaptations with reduced or increased loading, are reflected by the activation of a genetic program, which involves the copying (expression) of genes. Measurement of this expression response allows conclusions on the efficiency and specificity of a muscle stimulus (Fig. 4). Specific gene polymorphisms of major structural and metabolic regulators are recognised to explain inter-individual responsiveness to mechanical and metabolic stimuli. Currently we work towards testing the influence of specific gene polymorphisms on the effectiveness of exercise treatments. The goal is to develop personalised approaches that circumvent, or reverse muscle loss by maximising plasticity of the musculoskeletal system. Our model offers a platform for interactions with commercial partners aimed at tackling this major health problem of our post-industrial society.

An important aspect of our research concerns the clinical observation that the loss of myofibrillar material in fully unloaded muscle goes in parallel with an increase in muscle fat content. This is for instance indicated after tears of a tendon or ligaments (Fig. 5). This is a relatively frequent situation, affecting as many

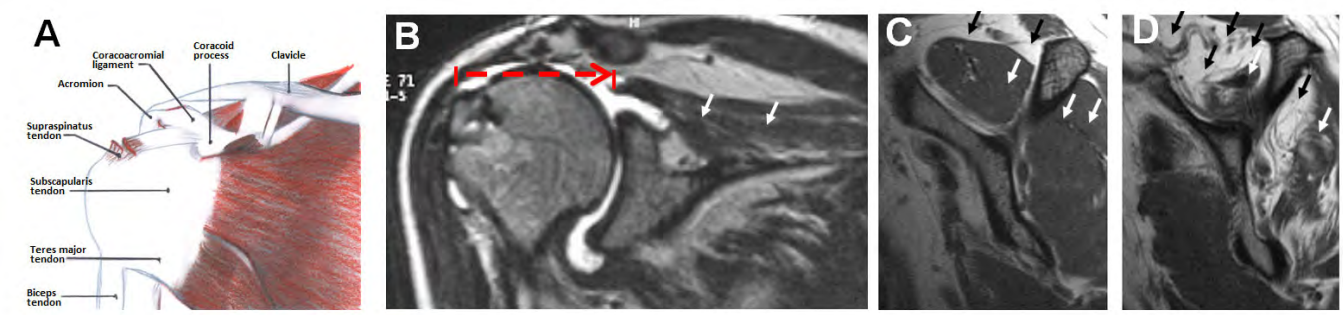



Figure 5: Fatty degeneration with tears of rotator cuff muscle. A) Drawing of the human rotator cuff with the indication of a rupture of supraspinatus tendon. B) Coronary and C,D) Sagittal images of a MRI scan of the shoulder of a patient at two time points after a full tear of the supraspinatus muscle tendon. The rate of retraction respective to the site of supraspinatus tendon attachment is indicated with a stippled, red arrow in panel A. Fat tissue (indicated by black arrows) appears in white above the darker contrast of muscle and bony tissue (white arrows).

as 100 per 100,000 persons each year for joints of the locomotor system such as in the anterior cruciate ligament. The highest incidence is seen for rotator cuff muscles of the shoulder, affecting two out of five individuals above sixty years of age. The observations highlight that mechanical factors govern the conversion of muscle into fat tissue. This implies that the muscle unloading produces defects in energy supply, which may culminate into a fatty degeneration of muscle cells.

At the same time, high-load type training of weak muscles based on eccentric contractions appears to reduce the lipid content of muscle tissue. The relationship between muscle atrophy and the accumulation of metabolic stores is poorly understood; yet this has large implications for control of body homeostasis. Nutritional factors aside, the usage and load-dependent preservation of muscle mass may importantly contribute to the variability in the relationship between contractile and fat tissue in healthy human populations (Fig. 6). This observation suggests that mechano-regulation of muscle mass is related to obesity, which is one of the largest co-factors for morbidity in the western civilisation.

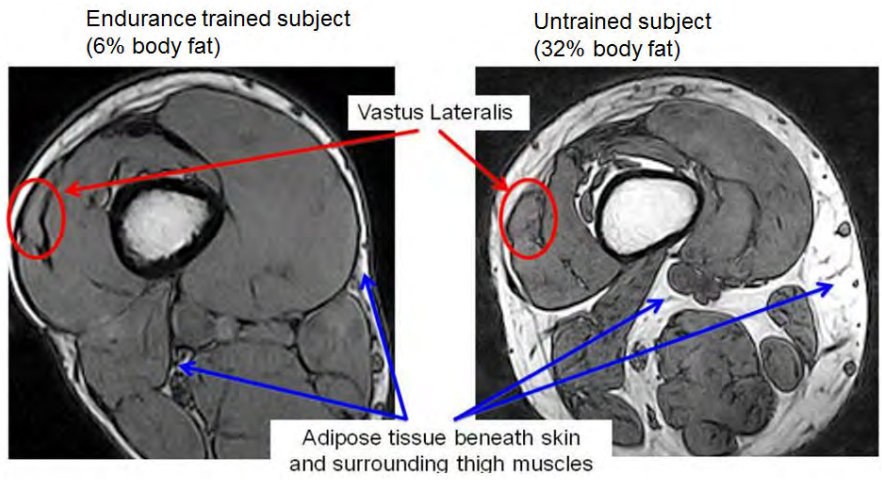
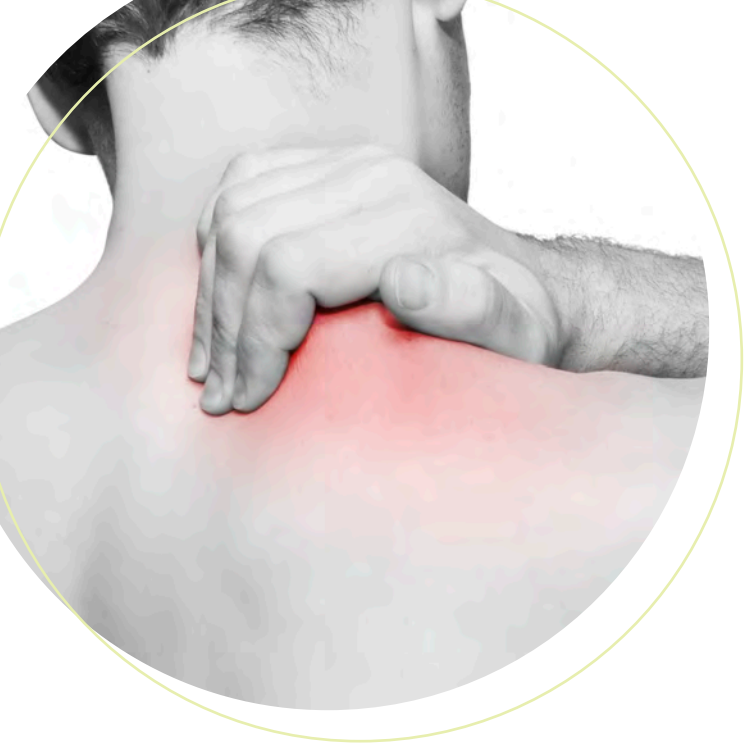



Figure 6: Increased extramyocellular fat with relative inactivity. Magnet resonance images showing the cross-sectional area of the thigh at a standardised, anatomical position in a trained and untrained subject of the same age. The increase in adipose tissue at the expense of the quadriceps and hamstring muscle area can be readily identified from the indications. The area corresponding to the vastus lateralis muscle is indicated by red circles. *Picture courtesy of D Vaughan (2012).*

The Balgrist

**Professor Martin Flück**
**Balgrist University Hospital**
**8008 Zurich / Switzerland**
**Tel: +41 44 386 3791**
**www.balgrist.ch**



"We provide excellent medical service with you, the patient, in mind."

*Prof. Martin Flück*