

## P12: Muscle Stiffness As Key Term For Understanding Human Locomotion

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**Background:** The forces, the body is loaded with, cause not only physiologic stimulation of muscle growth and bone modelling, but also defects. Therefore daily movements are designed to minimize these forces, in order to minimize the number of defects and the energy demand. With a given kinetic energy the only way to modulate the force loading is the variation of stiffness during eccentric movements. On hitting the ground during walking, running or jumping the muscle-tendon system acts as spring and/or damper, either storing or absorbing energy.

The ground force can be seen as total amount of force, acting on the body. The force peak depends on the breaking distance, which is the result of the body stiffness. The higher the stiffness, the smaller is the breaking distance, and the higher the ground reaction forces.

With the Leonardo mechanography ground reactions forces can be measured continuously with a sampling rate of 800 Hz. The system calculates out of force and mass the acceleration at every sample point. Integration of acceleration over time leads to velocity of the center of mass, and the product of force and velocity results in power. The body stiffness is calculated as ratio of force per distance. The distance is the way of the center of mass from landing to the lowest point. Cf. the characterisation of a spring: How much force is necessary for a certain elongation. On this background the somewhat vague term "coordination" can be conceptualized as continuous adaptation of body stiffness to the demands of the current motor task.

Calculating the forces acting on the body is necessary for designing an effective osteoanabolic exercise program.

**Objectives:** To measure force loading and stiffness during typical exercise movements by means of mechanography (Leonardo<sup>TM</sup> force plate, Novotec Medical, Pforzheim, Germany) as a basis for a rational planning of osteo-anabolic exercises.

**Setting and participants:** Muscle-bone center of a Geriatric clinic. Healthy and fit volunteers (young adults and elderly) and different groups of patients.

**Methods:** Performing usual every day movements and clinically relevant exercises as rising from a sitting position, vertical jumping, or jogging in place on a Leonardo<sup>TM</sup> force plate.

**Results:**

- chair rising generates unilateral peak forces of about 0,8 x body weight.
- jogging in place on the ball of the feet generates unilateral ground reaction forces of about 2 x body weight.
- fast stair climbing generates unilateral about the 1,8 x body weight.
- hopping on one leg generates more than 3 x body weight,
- unilateral osteoarthritis generates habitual side differences in stiffness and force loading

**Discussion:** To understand, to plan and to evaluate physical exercises an exact knowledge of applied forces on the musculoskeletal system is required. Measuring ground reaction forces and stiffness on serial jumping is a feasible method to measure side-different force loading in unilateral disorders. Referring to the lever conditions of the foot ground reaction forces of 3fold body weight mean, that more the 12fold force of body weight is applied to the bones and joints of the lower leg. This "physiologic" level of force has to be considered, if exercise programs should be assessed in relation to the regulation of bone strength.