A number of short-duration intervention studies have demonstrated that physical training can counteract the aging- and inactivity-related muscle wasting and weakness as well as bone loss (e.g. Reaburn, Dascombe Eur Rev Aging Phys Act 2009). Nevertheless, little is known how long-term physical training on regular basis affects the aging musculoskeletal system. It has been emphasized that habitually-trained middle-aged and older "masters" or "veteran" athletes (>35 yrs) are unique in that their musculoskeletal system has been subjected to a great amount of stress over many years. The theory is that in master athletes full capacity to adapt to specific exercise stimulus has been utilized and that any age-related changes in their musculoskeletal system reflect mainly the aging process itself (e.g. Lazarus, Harridge Scand J Med Sci Sports 2007). However, to date there are only few large-scale masters athlete studies, particularly longitudinal ones, which provide evidence of a causal relationship between observed physiological changes, training, and aging.

AIMS
The overall aim of this international and interdisciplinary project is to increase the understanding of the possibility of different exercise modalities to slow the aging processes in skeletal muscle and bone characteristics. The specific aims and hypotheses are as follows:

Aim #1: To describe age-related changes in lower limb musculoskeletal properties in male and female sprint/power-, endurance- and strength-trained athletes and untrained people.

Hypothesis #1: Typical age-related deterioration in muscle quality (e.g. specific force, single-fiber contractility, intramuscular fat) can be prevented by all three exercise modalities. Strength training and to a moderate extent sprint training are effective in limiting muscle atrophy while endurance training is of lesser value in maintaining muscle mass with age. In older age bone mineral content and density decline in athletes but are maintained clearly above osteopenia and osteoporosis thresholds (Fig. 1). The protective effect of training on bone strength is related to sport-specific mechanical loading (sprint>strength>endurance).

Aim #2: To examine the effect of age on muscle and bone adaptation to 21-week combined sprint-strength training and to study the cellular and molecular factors underlying the muscle hypertrophy in male sprinters.

Hypothesis #2: Age will not impair the enlargement of muscle in response to strength training. In addition, lifetime sprinters do not exhibit age-related differences in satellite cell number, ability to incorporate new myonuclei or the levels of myogenic or apoptotic factors that are responsible for hypertrophy. Even a short-term intensive strength and speed training period will induce significant changes in bone strength in masters athletes.

The data for the project are derived from two ongoing longitudinal studies (Sprint study, Longitudinal field study) and one pre-existing experimental study (Strength training study). Sprint study includes Finnish male sprinters (17-84 yr, n=108) who will be re-examined in 2012, 10 years after baseline evaluation. Longitudinal field study is conducted in major international track and field championships to assess changes in bone and muscle properties in male and female athletes (35-90 yr, n=400) of different sporting events. Strength training study investigates the effectiveness of high-intensity strength training to further enhance skeletal muscle and bone characteristics in masters runners with weaker background in strength training compared to young athletes. The subjects were the 40-89-year-old men who participated in Sprint study and were randomly assigned into experimental (n=40) and control (n=32) groups.

MEASUREMENTS
• Bone characteristics (pQCT, DXA)
  - Tibial bone density, structure and strength
  - Areal bone density and structure of femoral neck and lumbar spine
• Whole-muscle structure (pQCT, ultrasound)
  - Muscle cross-sectional area and thickness
  - Pennation angle and fascicle length
• Intramuscular fat
• Muscle fiber properties (m. vastus lateralis)
  - Fiber type and size
• Single-fiber contractile properties
• Specific molecular and cellular factors
• Hormones, inflammatory cytokines, bone markers
• Strength and power performance

PRELIMINARY RESULTS
• Our recent results on bone properties indicate that training regularly in high-impact track and field sports with uneven lower limb loading (hurdling, jump events) increases tibial bone strength in the loaded dominant side independent of age and sex. This suggests that participation in sport activities with higher impacts is an effective method of maintaining bone strength throughout the adult life span (Ireland, Korhonen, et al. J Musculoskelet Neuronal Interact 2011).

• The good tibial bone strength of aging sprint athletes was mainly related to improved geometrical structure, whereas smaller adaptive effect was observed in bone density measures. Inter-individual differences in bone traits seem to be due to combined effects of exercise loading, body/muscle size and hormonal characteristics (Korhonen et al. Med Sci Sports Exerc 2012, Epub ahead of print).

• The collection of the longitudinal data continues until November 2012 and the first results will be presented in 2013.