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Effects of combined strength and sprint training on bone, muscle and performance characteristics in middle-aged and older sprint athletes

Submission date	Recruitment status	[ ] Prospectively registered
07/10/2016	No longer recruiting	[ ] Protocol
Registration date	Overall study status	[ ] Statistical analysis plan
17/10/2016	Completed	[X] Results
Last Edited	Condition category	[ ] Individual participant data
06/12/2021	Musculoskeletal Diseases	

Plain English summary of protocol

Background and study aims

Strong bones are essential for good overall health and quality of life during a person's lifetime. Aging, in combination with several factors such as reduced physical activity, leads to bones becoming more fragile, leading to problems such as osteoporosis (a condition where the bone becomes porous) and fractures. Intensive strength, power and impact types of training have good potential to strengthen bones even in old age. In adult bone the increase in bone strength may be more apparent in bone structural properties than bone density. The effects of exercise on bone structure among older people are, however, not well researched. Typical older people with low levels of exercise and bone strength might not tolerate or be able or willing to participate in such vigorous exercise that provokes these changes in bone tissue. In this study, the effects of combined strength and sprint training on bone properties are investigated in competitive masters sprinters with a long-term impact-training background. In addition, bone, muscle and physical performance characteristics of the athletes will be examined 10 years after the end of the study to look at long term effects. The aim is to examine the contribution of aging and maintained/reduced training on bone structure and strength. The long-term data is particularly important because it increases the understanding of benefits and risks of continuous impact-type training on the aging body.

Who can participate?

Competitive male masters sprinters aged 40-85 with long-term training background

What does the study involve?

Participants are randomly allocated to two groups. Those in the first group undergo a 20 week training program combining sprint training (two times per week) with heavy and explosive strength exercises (two times per week). Those in the second group are asked to maintain their usual, mostly running-based training programs. At the start of the study and then after 20 weeks, participants in both groups have their bodies scanned to look at bone and muscle structure, as well as completing a number of assessments to assess their strength, physical

condition and physical characteristics. After 10 years, participants are invited to another follow up assessment where these measures are repeated.

What are the possible benefits and risks of participating?
Participants benefit from receiving information about their bone strength and other physical characteristics, physical condition and speed characteristics. All the measurements are proven safe in numerous previous studies and will be performed by expert personnel. Maximal tests of physical performance include risks, but the athletes are, on average, in good physical condition and the risks are minimized with proper arrangements. First aid and study physician are available. Radiation doses associated with the scanning techniques used are very low and so pose little risk.

Where is the study run from?
Department of Health Sciences at the University of Jyväskylä (Finland)

When is study starting and how long is it expected to run for?
January 2002 to June 2019

Who is funding the study?
1. Finnish Ministry of Education and Culture (Finland)
2. Finnish Academy (Finland)

Who is the main contact?
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Contact information

Type(s)
Scientific

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Additional identifiers

Protocol serial number
N/A

Study information

Scientific Title
Effects of high-intensity strength and sprint training on tibial bone structure and strength in middle-aged and older sprint athletes: a randomized controlled trial

Acronym
Athlete Aging Study (ATHLAS)

Study objectives
1. Strength and sprint training increases bone strength in ageing sprint athletes by improving structural properties of tibial shaft and by adding density in distal tibia (randomized controlled trial)
2. In sprinters older age will not impair the improvement in physical performance or enlargement of muscle in response to combined training. In addition, the sprinters do not exhibit age-related differences in satellite cell number, ability to incorporate new nuclei or the levels of myogenic or apoptotic factors that are responsible for hypertrophy (randomized controlled trial)
3. Athletes who have continued intensive sprint training show less aging-associated changes in bone structure, density and strength over a period of 10 years than athletes who stopped competing and became physically less active (10-yr follow-up in the same sample)
5. Aging effects in structural and functional properties of muscle fibers (fiber type composition. capillary density, myonuclear domain and fiber size, specific tension, shortening velocity) are related to maintenance of training level (10-yr follow-up in the same sample)
6. Circulating molecules (FasL, miR-21 and miR-146a), regulating processes involved in training adaptations, are associated with physical performance measures and aging among competitive male masters sprinters (10-yr follow-up in the same sample)
7. α-actinin deficient athletes show greater decline in physical performance measures with increasing age (10-yr follow-up in the same sample)

Ethics approval required
Old ethics approval format

Ethics approval(s)
1. University of Jyväskylä Ethical Committee, 11/11/2002
2. Ethics Committee of the Central Finland Health Care District, 02/04/2012 and 12/10/2012 (10-year follow-up)

Study design
Single-centre randomized controlled trial with longitudinal follow up

Primary study design
Interventional

Study type(s)
Other

Health condition(s) or problem(s) studied
Musculoskeletal health and function

Interventions
Participants are randomised to one of two group:

Exercise group (EX): Participants participate in a 20-week program combining sprint training (2 times/wk) with heavy and explosive strength exercises (weightlifting and plyometrics, 2 times /wk). The program consists of two 11- and 9-week periods that were further divided into three phases of 3-4 weeks with different intensity, volume and type of training. The strength training focuses on the leg extensor and hamstring muscle groups and progresses from strength endurance and hypertrophy exercises to maximal strength and explosive strength exercises. Plyometric exercises progress from low intensity vertical jumps to horizontal bounding exercises. The sprint training program progresses from speed-endurance to maximum speed exercises.

Control group (CTRL): Participants are instructed to maintain their usual, mostly run-based training schedules.

Both groups keep detailed exercise diaries throughout the intervention period. Field tests for running performance and muscle power are organized in weeks 5, 10 and 15 in order to obtain feedback on the athlete’s training status and degree of progress.

Follow-up measurements are performed immediately after the 20-week training period. This part of the trial was completed on the 25th May 2003.

A 10-year follow-up measurement is performed for the participants who are willing to come back to the lab. The participants are contacted by telephone. 10-year follow-up includes identical measurements compared to baseline and 20 weeks follow-up, except for DEXA measurement which is done only in the follow-up. The 10-year follow-up is performed in order to study the effects of aging and continued/discontinued high-intensity sprint training on musculoskeletal and physical performance characteristics.

Intervention Type
Other

Primary outcome(s)
Bone structure and strength are measured by peripheral quantitative computed tomography (pQCT) at baseline, after 20 weeks training period and at the 10 year follow-up.

Key secondary outcome(s))
1. Bone mineral content and volumetric density are measured by pQCT at baseline, after 20 weeks training period and at the 10 year follow-up
2. Anthropometry and body composition are measured by bioimpedance device at baseline, after 20 weeks training period and at the 10 year follow-up
3. Whole-muscle structural characteristics (quadriceps, triceps surae) is measured by pQCT and ultrasound at baseline, after 20 weeks training period and at the 10 year follow-up
4. Muscle needle samples were obtained from the middle region of the vastus lateralis muscle under local anaesthesia. Muscle fiber type, structure and single fiber contractile properties are measured by ATPase histochemistry, immunohistochemistry and skinned fiber experimental apparatus at baseline, after 20 weeks training period and at the 10 year follow-up
5. Blood and serum samples were taken for genetic, hormone, cytokine, growth factor analyses at baseline, after 10 and 20 weeks of training and at the 10 year follow-up. Automated immunoassay systems or commercial ELISA kits are used for the analyses
6. Muscle strength and power of leg and knee extensors and knee flexors (including explosive strength capability assessed by squat jump, triple jump with a standing start and a reactive hopping test) are measured by David 200 dynamometer, Smith machine and custom made

dynamometry, force plate and contact mat at baseline, after 20 weeks training period and at the 10 year follow-up
7. Sprint running performance (30- and 60-meter) is measured on an indoor track equipped with a 9.4-m-long force platform by using double-beam photo-cell gates at baseline, after 20 weeks training period and at the 10 year follow-up.
8. Nutrient intake is obtained from 5-day food diaries kept in week 15 of the 20 weeks' training period.
9. Bone mineral content, areal bone mineral density, lean body mass and body fat of whole body are assessed by dual energy X-ray absorptiometry (DXA) at the 10-year follow-up. In addition, DXA images are used to assess lumbar vertebral microarchitecture (trabecular bone score, TBS) and the structural parameters of proximal femur (hip structure analysis, HSA).

Completion date
30/06/2017

Eligibility

Key inclusion criteria
1. Voluntary men aged ≥ 40 with long-term training background and success in international or national masters sprint events
2. Ongoing systematic training and competing
3. No diseases or musculoskeletal disorders contraindicating exercise or limiting participation in the training program

Participant type(s)
Healthy volunteer

Healthy volunteers allowed
No

Age group
Mixed

Sex
Male

Key exclusion criteria
1. Medical condition contraindicating intensive training
2. Use of medication affecting bone
3. Unwillingness to participate

Date of first enrolment
11/10/2002

Date of final enrolment
30/11/2002

Locations

Countries of recruitment

Finland

Study participating centre
University of Jyväskylä
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Sponsor information

Organisation
University of Jyväskylä

ROR
https://ror.org/05n3dz165

Funder(s)

Funder type
Government

Funder Name
Finnish Ministry of Education and Culture

Funder Name
Finnish Academy

Results and Publications

Individual participant data (IPD) sharing plan
The datasets generated during and/or analysed during the current study are/will be available upon request from Dr. Marko Korhonen (marko.t.korhonen@jyu.fi).

IPD sharing plan summary
Available on request

Study outputs

Output type	Details	Date created	Date added	Peer reviewed?	Patient-facing?
Results article		24/05/2021	06/12/2021	Yes	No
Participant information sheet	Participant information sheet	11/11/2025	11/11/2025	No	Yes