Association of exercise loading history with fall-induced hip fracture risk.

General information
State: Published
Organisations: Civil Engineering, Faculty of Biomedical Sciences and Engineering, Research group: Computational Biophysics and Imaging Group, UKK Institute for Health Promotion Research
Authors: Abe, S., Narra, N., Nikander, R., Hyttinen, J., Kouhia, R., Sievänen, H.
Publication date: 2017
Peer-reviewed: Unknown
Keywords: Hip fracture, Exercise, Finite element method (FEM), Bone strength, Falling
Links:

Influence of exercise history on fall-induced hip fracture risk.
Hip fracture is a major public health problem. Thin superolateral cortex of the femoral neck experiences unusually high stress in a sideway fall, contributing to hip fracture risk. The aim of this study is to examine how exercise based loading history, known to affect the femoral neck cortical structure, influences fall-induced fracture risk. For this purpose, finite element models were created from the proximal femur MRI of 91 young athletic and 20 control females. Fall-induced superolateral cortical safety factors (SF) were estimated in the distal volume of femoral neck. Significantly higher (p < 0.05) SFs were observed from femoral necks with high impact (H-I), odd impact (O-I), and repetitive impact (R-I) exercise history, indicating lower fracture risk. The results indicate that it is advisable to include some impact exercise in a fracture preventive exercise program.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Civil Engineering, Faculty of Biomedical Sciences and Engineering, Research group: Computational Biophysics and Imaging Group, UKK Institute for Health Promotion Research
Authors: Abe, S., Narra, N., Nikander, R., Hyttinen, J., Kouhia, R., Sievänen, H.
Number of pages: 4
Pages: 464-467
Publication date: 2017

Host publication information
Title of host publication: Proceeding of the 35th International Conference on Biomechanics in Sports: German Sport University Cologne, Cologne, Germany, June 14-18, 2017
Volume: 1
Editors: Potthast, W., Niehoff, A., David, S.
Keywords: Hip fracture, Exercise, Finite element method (FEM), Bone fracture, Bone strength, Falling
Links:
https://dshs-koeln.sciebo.de/index.php/s/CamALh9yXz0k6Vt#pdfviewer

Bibliographical note
EXT="Sievänen, Harri"
Research output: Scientific - peer-review › Conference contribution

Augmented inertial measurements for analysis of javelin throwing mechanics
This paper examines the exploitation of inertial measurements to analyze javelin throwing mechanics. The main objective was to demonstrate that consumer-grade inertial navigation systems, augmented with some position and attitude data obtained from a video sequence, yield detailed information of the mechanics of javelin throwing. Especially, such a system makes it possible to analyze the momentary force and power exerted on the javelin during the acceleration phase. Although the presented system is a pilot, leaving space for further improvements, it already reveals the potential of inertial navigation systems to sports. In practice, an inertial measurement unit was embedded inside the tip of the javelin to determine the javelin’s momentary attitude, position, and velocity. Graphs on the speed and angular velocity about the longitudinal axis of the javelin during the whole performance are presented. The maximum estimated release speed and release angular speed were 28.02 m/s and 215.9 rad/s, respectively. The acceleration phase trajectory of the javelin and its deviation from a straight line path are demonstrated. Additionally, the momentary forces and powers are shown and the effect of aerodynamic forces on the projectile is specified. The magnitude of the maximum tangential forces and accelerating powers were 364 N and 9.76 kW. The duration and length of the acceleration phase trajectory varied between 223 and 231 ms, and 2.48 and 2.75 m. To estimate the accuracy of the inertial measurements, the acceleration phase results were compared to measurements made with high-speed cameras.
Exercise loading history and femoral neck strength in a sideways fall: A three-dimensional finite element modeling study.

Over 90% of hip fractures are caused by falls. Due to a fall-induced impact on the greater trochanter, the posterior part of the thin superolateral cortex of the femoral neck is known to experience the highest stress, making it a fracture-prone region. Cortical geometry of the proximal femur, in turn, reflects a mechanically appropriate form with respect to habitual exercise loading. In this finite element (FE) modeling study, we investigated whether specific exercise loading history is associated with femoral neck structural strength and estimated fall-induced stresses along the femoral neck. One hundred and eleven three-dimensional (3D) proximal femur FE models for a sideways falling situation were constructed from magnetic resonance (MR) images of 91 female athletes (aged 24.7±6.1 years, >8 years competitive career) and 20 non-competitive habitually active women (aged 23.7±3.8 years) that served as a control group. The athletes were divided into five distinct groups based on the typical loading pattern of their sports: high-impact (H-I: triple-jumpers and high-jumpers), odd-impact (O-I: soccer and squash players), high-magnitude (H-M: power-lifters), repetitive-impact (R-I: endurance runners), and repetitive non-impact (R-NI: swimmers). The von Mises stresses obtained from the FE models were used to estimate mean fall-induced stresses in eight anatomical octants of the cortical bone cross-sections at the proximal, middle, and distal sites along the femoral neck axis. Significantly (p<0.05) lower stresses compared to the control group were observed: the H-I group - in the superoposterior (10%) and posterior (19%) octants at the middle site, and in the superoposterior (13%) and posterior (15%) octants at the distal site; the O-I group - in the superoposterior (14%) and posterior (23%) octants at the middle site, and in the superoposterior (19%) and posterior (20%) octants at the distal site. The R-I group - in the superoposterior (14%) and posterior (22%) octants at the middle site, and in the superoposterior (19%) and posterior (20%) octants at the distal site. The R-NI group did not differ significantly from the control group. These results suggest that exercise loading history comprising various impacts in particular is associated with a stronger femoral neck in a falling situation and may have potential to reduce hip fragility.
### Publication information

**Journal:** Bone  
**Volume:** 92  
**ISSN (Print):** 8756-3282  
**Ratings:**

<table>
<thead>
<tr>
<th>Year</th>
<th>SJR</th>
<th>SNIP</th>
<th>CiteScore</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>1.612</td>
<td>1.427</td>
<td>4.09</td>
</tr>
<tr>
<td>2015</td>
<td>1.757</td>
<td>1.527</td>
<td>4.17</td>
</tr>
<tr>
<td>2014</td>
<td>1.794</td>
<td>1.656</td>
<td>4.18</td>
</tr>
<tr>
<td>2013</td>
<td>1.843</td>
<td>1.73</td>
<td>4.55</td>
</tr>
<tr>
<td>2012</td>
<td>1.644</td>
<td>1.591</td>
<td>4.09</td>
</tr>
<tr>
<td>2011</td>
<td>1.82</td>
<td>1.628</td>
<td>4.33</td>
</tr>
<tr>
<td>2010</td>
<td>1.785</td>
<td>1.657</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>1.759</td>
<td>1.593</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>1.848</td>
<td>1.515</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>1.841</td>
<td>1.52</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>1.758</td>
<td>1.517</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>1.671</td>
<td>1.646</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>1.329</td>
<td>1.483</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>1.456</td>
<td>1.344</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>1.511</td>
<td>1.551</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>1.479</td>
<td>1.666</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>1.411</td>
<td>1.438</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>1.323</td>
<td>1.58</td>
<td></td>
</tr>
</tbody>
</table>

**Original language:** English  
**ASJC Scopus subject areas:** Orthopedics and Sports Medicine, Biochemistry, medical, Physical Therapy, Sports Therapy and Rehabilitation  
**Keywords:** Bone strength, Finite element analysis, Exercise, Falling, OSTEOPOROSIS, Hip fracture  
**DOIs:**  
10.1016/j.bone.2016.07.021  
**Links:**  
**Research output:** Scientific - peer-review › Article