


**Please cite the Published Version**

Cheng, S, Degens, H , Evans, M, Cheng, SM, Selänne, H, Rittweger, J, Heinonen, A, Suominen, H, Strandberg, T, Alen, M and Korhonen, MT (2016) What makes a 97-year-old man cycle 5,000 km a year? *Gerontology: international journal of experimental, clinical, behavioral, regenerative and technical gerontology*, 62 (5). pp. 508-512. ISSN 0304-324X

**DOI:** <https://doi.org/10.1159/000443390>

**Publisher:** Karger Publishers

**Version:** Accepted Version

**Downloaded from:** <https://e-space.mmu.ac.uk/601126/>

**Usage rights:**  In Copyright

**Additional Information:** This is an Accepted Manuscript of an article accepted for publication in the *Gerontology*, copyright S. Karger AG.

**Enquiries:**

If you have questions about this document, contact [openresearch@mmu.ac.uk](mailto:openresearch@mmu.ac.uk). Please include the URL of the record in e-space. If you believe that your, or a third party's rights have been compromised through this document please see our Take Down policy (available from <https://www.mmu.ac.uk/library/using-the-library/policies-and-guidelines>)

# 1 **What makes a 97-year-old man cycle 5 000 km a year?**

## 2 **Albert Einstein**

3 **“Life is like riding a bicycle. To keep your balance, you must keep**  
4 **moving”**

5

6 Sulin Cheng<sup>a,b\*</sup>; Hans Degens<sup>c,i</sup>; Michael Evans<sup>c</sup>; Shu Mei Cheng<sup>b</sup>; Harri  
7 Selänne<sup>d</sup>; Jörn Rittweger<sup>e</sup>; Ari Heinonen<sup>b</sup>; Harri Suominen<sup>b</sup>; Timo  
8 Strandberg<sup>f</sup>; Markku Alen<sup>g\*</sup>; Marko T. Korhonen<sup>h\*</sup>

9

10 <sup>a</sup> Exercise Health and Technology Centre, Shanghai Jiao Tong University,  
11 Shanghai, China.

12 <sup>b</sup> Department of Health Sciences, University of Jyväskylä, Jyväskylä,  
13 Finland.

14 <sup>c</sup> School of Healthcare Science, Neuromuscular and Skeletal Ageing  
15 Research Group, Manchester Metropolitan University, Manchester, United  
16 Kingdom.

17 <sup>d</sup> LIKES Research Center, Jyväskylä, Finland.

18 <sup>e</sup> The German Aerospace Center, Institute of Aerospace Medicine, Cologne,  
19 Germany.

20 <sup>f</sup> University of Helsinki and University Central Hospital, Geriatrics;  
21 University of Oulu, Oulu, Finland.

22 <sup>g</sup> Department of Medical Rehabilitation, Oulu University Hospital; Institute  
23 of Health Sciences, University of Oulu, Oulu, Finland.

24 <sup>h</sup> Gerontology Research Center, Department of Health Sciences, University  
25 of Jyväskylä, Jyväskylä, Finland.

26 <sup>i</sup> Lithuanian Sports University, Kaunas.

27

28 \* These authors contributed equally to this work.

29

30 Corresponding author: Sulin Cheng, PhD, Professor  
31 Exercise Health and Technology Centre, Shanghai Jiao  
32 Tong University, 800 Dongchuan Rd, 200240 Shanghai,  
33 China,  
34 and Department of Health Sciences, University of  
35 Jyväskylä, PO Box 35 40014 Jyväskylä, Finland

36

Phone: +358 40 5580209

37

Email: [sulin.cheng@jyu.fi](mailto:sulin.cheng@jyu.fi)

38 **ABSTRACT**

39 *Background:* The nature versus nurture debate is one of the oldest issues  
40 in the study of longevity, health and successful aging. *Objective:* We  
41 present a 97-year-old man (IK) as an example of the effects of habitual  
42 exercise on the aging process. *Methods:* Extensive assessments included  
43 medical examinations, interviews, musculoskeletal structure, performance  
44 characteristics, cognitive function and gut microbiota composition.  
45 *Results:* IK suffers from iatrogenic hypogonadism, prostate cancer,  
46 hypothyroidism and a history of deep popliteal thrombosis.  
47 Notwithstanding, he cycles up to 5000 km a year and participates in  
48 competitive sports. His musculoskeletal properties, athletic performance,  
49 cognitive function and gut microbiota are outstanding. Some traits even  
50 exceed those seen in middle-aged men. *Conclusions:* His long-term  
51 physical and intellectual active lifestyles combined with extensive social  
52 interactions have most likely contributed to his exercise capacity, despite  
53 his medical history.

54

55 *Short title:* Successful aging in the older athlete56 *Keywords:* Aging, Cognition, Healthy aging, Lifestyle, Longevity, Sports

## 57 **INTRODUCTION**

58 Only 362 (0.9%) of all Finnish men born 1918 were still alive in 2014 [1].  
59 Most of those who survive to age 90 have cardiovascular (ca. 80%),  
60 musculoskeletal (47%), cognitive (26%), and/or neurological (12%)  
61 conditions that limit their functional ability for independent living [2].  
62 Previous studies have shown that, after age 80, a lifestyle that  
63 incorporates regular endurance training helps to maintain optimal  
64 functioning of numerous physiological systems [3]. Besides aerobic  
65 capacity, adequate muscle strength is crucial for functional status [4] and  
66 might, independent of aerobic capacity, increase longevity [5]. However,  
67 'rest in old age' is a common paradigm and many elderly people remain  
68 well below their functional capacity potential owing to a sedentary  
69 lifestyle [6]. In this case report, we argue that the exceptional physical  
70 and cognitive functioning of a 97-year-old man (IK), despite chronic  
71 diseases, is due to the combination of healthy lifestyle factors that he has  
72 maintained from his early years onwards (**Figure 1**).

73

## 74 **METHODS**

75 Information on IK's family background, occupational history, living habits,  
76 social contacts, physical training and competition history were obtained  
77 through interviews. Competition performances were verified from official  
78 statistics. General health status was evaluated by a physician. Copies of  
79 earlier medical records, including the results of a 10-min exercise-  
80 tolerance test on a cycle ergometer were obtained from IK.  
81 Anthropometry, body composition (DXA), functional capacity were

82 assessed and muscle biopsies taken as described elsewhere [7]. Life-  
83 satisfaction was evaluated with Allardt's scale [8]. Cognitive function was  
84 determined by the CERAD and Trail-making (TMT) tests [9] and  
85 psychomotor speed with reaction time tests [10]. Gut microbiota  
86 composition was derived from sequences of the 16S rRNA gene in fecal  
87 DNA samples using ultra-high-throughput microbial community analysis  
88 on the Illumina MiSeq platforms [11]. The Ethics Committee of the Central  
89 Finland Health Care District approved the study. IK provided a written  
90 informed consent to use his personal data, including medical records,  
91 photographs and test results.

92

## 93 **RESULTS**

### 94 **Life and occupational history**

95 In January 2015, IK was 97, an age well above the average 43-year life  
96 expectancy of Finnish men born in 1918 [12]. IK married in 1943, had a  
97 family and was widowed in 2007. His parents died when he was young (his  
98 mother died in 1924 from pneumonia at age 37 and his father in 1930  
99 from colon cancer at age 43). At age 12, IK and his siblings lived in foster  
100 families of similar socio-economic background to his biological family and  
101 lived in the countryside. He joined the army during the war (1939-1945),  
102 and obtained an engineering diploma in 1948. Most of his professional  
103 career (1950-1973) was spent as a land surveyor. In 1974, he became an  
104 associate professor at Helsinki University of Technology and retired in

105 1981. After retirement, IK maintained his interest in alcohol-related health  
106 issues, occasionally lecturing on healthy living.

107 IK is optimistic and has a positive attitude to work, colleagues, friends and  
108 life in general. To date, he is still living independently, using a bicycle and  
109 car to shop and meet friends, and traveling by train to participate in  
110 athletic competitions. He regularly takes part in weekly meetings with  
111 other war veterans. Other hobbies include singing in a church choir, piano  
112 playing and reading.

113

#### 114 **Health characteristics**

115 IK was healthy throughout most of his childhood and adult working years.  
116 He has never smoked or used alcohol. He had gallstones in 1968 and  
117 spondylosis of the cervical/lumbar spine in 1978. He has been operated  
118 for left and right carpal tunnel syndrome and in 2010 was diagnosed with  
119 hypothyroidism. Prostate cancer was detected and treated effectively with  
120 radiotherapy in 2004, but recurred in 2012. The orchiectomy resulted in  
121 secondary hypogonadism and serum testosterone concentrations below  
122 the detection level. He had deep venous thrombosis twice (2012 and  
123 2013), and now requires continuous oral antithrombotic medication. The  
124 medical records from the last two decades indicate that his resting blood  
125 pressure (130–145/74–80 mmHg), serum total cholesterol (4.4–4.9  
126 mmol/L), triglycerides (1.3–1.4 mmol/L), S-HDL (1.1–1.4 mmol/L), S-LDL (2.8–3.2  
127 mmol/L) and fasting blood glucose (5.7–6.1 mmol/L) values have  
128 all been in healthy levels.

129 IK has a well-balanced gut microbiota composition; he had a much lower  
130 proportion of Gram-positive *Firmicutes*, but a higher proportion of Gram-  
131 negative *Bacteroidetes* bacteria, than obese subjects (unpublished  
132 observations). Three-day food diaries indicated a 27% decline in daily  
133 total energy intake from 2270 kcal (carbohydrates 58%, protein 14% and  
134 fat 28%) in 2002 to 1650 kcal (carbohydrates 50%, protein 18% and fat  
135 32%) in 2014.

### 136 **Life-time exercise habits**

137 From age six onwards he began his lifelong participation in sports,  
138 including cycling, track and field athletics, bandy ball, Finnish baseball,  
139 orienteering, cross-country skiing and gymnastics. During middle-age, he  
140 focused more on endurance-type sporting activities. After retirement, he  
141 resumed track and field athletics and continued competitive orienteering  
142 and skiing. At age 60, his major event was the decathlon. With advancing  
143 age, he shifted his interest to hurdles and lately to short sprints, long  
144 jump, triple jump, shot put and walking. The number of competitions he  
145 entered after age 70 is shown in **Figure 2a**. In 2000 and 2009, he was  
146 European and world champion hurdler. IK holds the world record for the  
147 300-m hurdles in the 90-94 age group, and indoor world records for the  
148 3000-m walk in the age groups 90-94 and 95-99. His jump performance  
149 declined significantly after age 75, whereas his sprint performance was  
150 not markedly impaired until his 90s (**Figure 2b and c**). Furthermore, his  
151 annual outdoor cycling distances at ages 94-96 were 3900 km, 3700 km  
152 and 5200 km, respectively. By the end of November 2015, he had again  
153 already covered over 5100 km. Personal fitness and setting an



154 encouraging example that older people can do regular exercise even  
155 when suffering from severe diseases, are important reasons for IK to  
156 participate in sports. He emphasizes that external support is important to  
157 remain active.

158

### 159 **Physical, musculoskeletal and performance characteristics**

160 Between age 20 and 97, his height declined from 168 to 162 cm, but his  
161 body mass remained relatively stable (between 67 and 74 kg). At age 95,  
162 he had a lower body mass index (IK: 26.5 vs. 45-year-old men: 27.3  
163 kg/m<sup>2</sup>), and a higher proportion of fat-free mass (IK: 74.6 vs. 45-year-old  
164 men: 73.2%) and bone mass (IK: 4.1 vs. 45-year-old men: 3.8%) per unit  
165 of body mass than the average 45-year-old man. His total calf muscle  
166 cross-sectional area (76 cm<sup>2</sup>) remained unchanged between 2002 and  
167 2012. His decline in maximal muscle force was only a third of his loss of  
168 explosive strength and his average sprint speed over 60 and 100 m  
169 decreased by 31% and 37%, respectively, between 2002 and 2012  
170 (**Figure 3**). The proportion of fast type II fibers in *m. vastus lateralis*  
171 decreased from 43% in 2002 to 19% in 2012. At age 86, his maximal  
172 workload in the exercise-tolerance test was 150 W, peak heart rate 139  
173 b/min, and peak blood pressure 180/80 mmHg. His estimated  $Vo_{2max}$  was  
174 27 mL/kg/min (7.7 MET). Six minutes later, his test blood pressure (130/80  
175 mmHg) and heart rate (80 b/min) had returned to resting levels.

### 176 **Cognitive function**

177 Based on the CERAD results, his overall global cognition, language and  
178 memory were 15-50% better than those in other non-demented 95-year-  
179 olds [9]. IK's motor speed (TMT-A, 36 s) and mental flexibility (TMT-B, 126  
180 s) scores surpassed those of age-matched subjects ( $85\pm 43$  vs.  $241\pm 78$  s,  
181 respectively) [9]. His simple reaction time (visual signal; 451 ms) and  
182 choice reaction time (657 ms) were comparable to those in 31- to 35-year-  
183 old men ( $473\pm 138$  vs.  $669\pm 117$  ms) in our laboratory using exactly the  
184 same tests and equipment [10]. Magnetic resonance imaging of his brain  
185 in 2015 revealed normal cortex structures, normal brain vasculature  
186 without microinfarcts or bleeds, but an age-related reduction in white  
187 matter volume.

188

## 189 **DISCUSSION**

190 We have described a 97-year-old man who still actively participates in  
191 athletic competitions, cycles up to 5000 km a year and lives  
192 independently, despite age-related medical conditions such as prostate  
193 cancer and hypothyroidism. This individual is an example of successful  
194 aging, and the comprehensive documentation of his life, career and  
195 sporting activities may help uncover the lifestyle factors responsible for  
196 high-level functioning in old age.

197 The exceptional functional capacities, health and longevity of IK may be  
198 attributable to his genetic constitution. Indeed, as a number of twin and  
199 family studies suggest that during aging various aspects of physical  
200 functioning, level of leisure time physical activity and health are

201 influenced by genotype [13]. While genetics may play some role, it is  
202 unlikely the most important factor, as he is the only one of his family who  
203 has lived to a very old age. We suggest that rather than a fortunate set of  
204 genes, IK's exceptional functional capacity, health and longevity is  
205 primarily attributable to a healthy lifestyle that includes high activity  
206 levels, a good diet that is associated with an advantageous microbiota  
207 composition, continued social interactions and the absence of other  
208 harmful risk factors.

209 IK's aerobic power at age 86 (27 ml/kg/min) was within the range reported  
210 for octogenarian lifelong endurance athletes [3]. His explosive muscle  
211 strength and speed performance, but not muscle mass, had decreased  
212 between age 82 and 92. This decline in rapid force production and sprint  
213 performance was probably due to the shift towards a slower fiber-type  
214 profile. Nevertheless, at 97, IK has no difficulties in daily life tasks, such as  
215 climbing stairs, and can even run a 100-m race. It is likely that his  
216 continued physical exercise has not only helped to overcome the potential  
217 negative effects of hypogonadism, hypothyroidism and prostate cancer,  
218 but also enabled him to cycle up to 5000 km a year and participate  
219 successfully in athletic competitions.

220 In 165 59-81-year-old men and women, high aerobic fitness was  
221 associated with larger hippocampal volumes and better spatial memory  
222 [14]. This and other studies suggest that exercise can reverse or  
223 attenuate the age-related cognitive decline. IK's overall global cognition,  
224 language and memory were 15-50% better than those reported in non-  
225 demented 95-year-olds and the difference in performance was even larger

226 in TMT tests requiring processing speed and executive functioning [9]. The  
227 maintenance of excellent cognitive abilities may partly be associated with  
228 lifetime exercise training. However, other factors such as educational  
229 background, social relations, studying and musical training into old age  
230 may also have contributed to IK's high cognitive function [15].

231 These data indicate that this elderly athlete has maintained exceptional  
232 overall physical and cognitive capabilities, and psychologic well-being,  
233 despite hypogonadism and other pathological conditions. His example  
234 suggests that an active lifestyle with a positive mental attitude and good  
235 health habits is the key to the successful aging.

236

## 237 **ACKNOWLEDGMENTS**

238 The authors would like to acknowledge the contribution of Eveliina  
239 Munukka to the gut microbiota analysis. The study was supported by the  
240 Academy of Finland (250683), Finnish Ministry of Education and Culture  
241 (100/627/2012), Juho Vainio Foundation, and Shanghai Jiao Tong University  
242 Zhiyang Foundation (CP2014013).

243

## 244 **REFERENCES**

- 245 1 Statistics finland: Official Statistics of Finland (OSF): Deaths [e-publication].  
246 Helsinki, ISSN=1798-2545. 01 2013, 2013.
- 247 2 Goebeler S: Health and illness at the age of 90: University of Tampere, School  
248 of Public Health, Tampere, , 2009, PhD, pp 110.
- 249 3 Trappe S, Hayes E, Galpin A, Kaminsky L, Jemiolo B, Fink W, Trappe T, Jansson  
250 A, Gustafsson T, Tesch P: New records in aerobic power among octogenarian  
251 lifelong endurance athletes. *J Appl Physiol* (1985) 2013;114:3-10.
- 252 4 Frontera WR, Bigard X: The benefits of strength training in the elderly.  
253 *Science Sports* 2002;17:109-116.

- 254 5 Ruiz JR, Sui X, Lobelo F, Morrow JR, Jr., Jackson AW, Sjostrom M, Blair SN:  
 255 Association between muscular strength and mortality in men: Prospective  
 256 cohort study. *BMJ* 2008;337:a439.
- 257 6 Booth FW, Laye MJ, Roberts MD: Lifetime sedentary living accelerates some  
 258 aspects of secondary aging. *J Appl Physiol* (1985) 2011;111:1497-1504.
- 259 7 Korhonen MT, Cristea A, Alen M, Hakkinen K, Sipila S, Mero A, Viitasalo JT,  
 260 Larsson L, Suominen H: Aging, muscle fiber type, and contractile function in  
 261 sprint-trained athletes. *J Appl Physiol* (1985) 2006;101:906-917.
- 262 8 Koivumaa-Honkanen H, Honkanen R, Viinamaki H, Heikkila K, Kaprio J,  
 263 Koskenvuo M: Life satisfaction and suicide: A 20-year follow-up study. *Am J*  
 264 *Psychiatry* 2001;158:433-439.
- 265 9 Whittle C, Corrada MM, Dick M, Ziegler R, Kahle-Wroblewski K, Paganini-Hill A,  
 266 Kawas C: Neuropsychological data in nondemented oldest old: The 90+  
 267 study. *J Clin Exp Neuropsychol* 2007;29:290-299.
- 268 10 Heikkinen E, Arajärvi R-L, Era P, Jylhä M, Kinnunen V, Leskinen A-L, Leskinen  
 269 E, Mässeli E, Pohjolainen P, Rahkila P, Suominen H, Turpeinen P, Väisänen M,  
 270 Österback L: Functional capacity of men born in 1906-1910, 1926-30 and  
 271 1946-50. A basic report. *Scand J Soc Med* 1984;Suppl 33:1-93.
- 272 11 Caporaso JG, Lauber CL, Walters WA, Berg-Lyons D, Huntley J, Fierer N, Owens  
 273 SM, Betley J, Fraser L, Bauer M, Gormley N, Gilbert JA, Smith G, Knight R:  
 274 Ultra-high-throughput microbial community analysis on the illumina hiseq  
 275 and miseq platforms. *ISME J* 2012;6:1621-1624.
- 276 12 Kannisto V, Nieminen M, Turpeinen O: Finnish life tables since 1751. *Demogr*  
 277 *Res* 1999;1
- 278 13 Frederiksen H, Christensen K: The influence of genetic factors on physical  
 279 functioning and exercise in second half of life. *Scand J Med Sci Sports*  
 280 2003;13:9-18.
- 281 14 Erickson KI, Prakash RS, Voss MW, Chaddock L, Hu L, Morris KS, White SM,  
 282 Wojcicki TR, McAuley E, Kramer AF: Aerobic fitness is associated with  
 283 hippocampal volume in elderly humans. *Hippocampus* 2009;19:1030-1039.
- 284 15 Seinfeld S, Figueroa H, Ortiz-Gil J, Sanchez-Vives MV: Effects of music learning  
 285 and piano practice on cognitive function, mood and quality of life in older  
 286 adults. *Front Psychol* 2013;4:810.
- 287  
 288  
 289  
 290

## 291 **FIGURE LEGENDS**

292 **Figure 1** □ IK at age 91 in the World Masters Athletic Championships  
 293 (2009, Lahti, Finland. Photo: Ken Stone/Masterstrack.com).

294 **Figure 2.** Frequency of participation in competitive sport events (*a*, dot  
 295 represents competition times at given age) and personal best  
 296 results in sprinting (*b*, dot represents speed records in seconds  
 297 at given age) and jumping (*c*, dot represents jumping records in  
 298 meters at given age) between the age 65 and 97.

299 **Figure 3.** Percentage change in maximal and explosive muscle strength,  
 300 and in sprint performance over 10 years (from 2002 to 2012, age  
 301 85 to 95). Maximal isometric strength of right leg knee extensors  
 302 ( $MVC_{KER}$ ) and left leg knee extensors ( $MVC_{KEL}$ ); right knee flexors  
 303 ( $MVC_{KFR}$ ) and left knee flexors ( $MVC_{KFL}$ ); arm extensors (Bench  
 304 Press); maximal rate of force development in isometric bilateral  
 305 leg extension ( $RFD_{BLE}$ ); vertical countermovement jump height



306 (CMJ); standing start triple jump (STJ) and running triple jump  
 307 distance (RTJ); and average speed in 60- and 100-m sprint.

308

309

310

311 **Figure 1.**

312

313

314

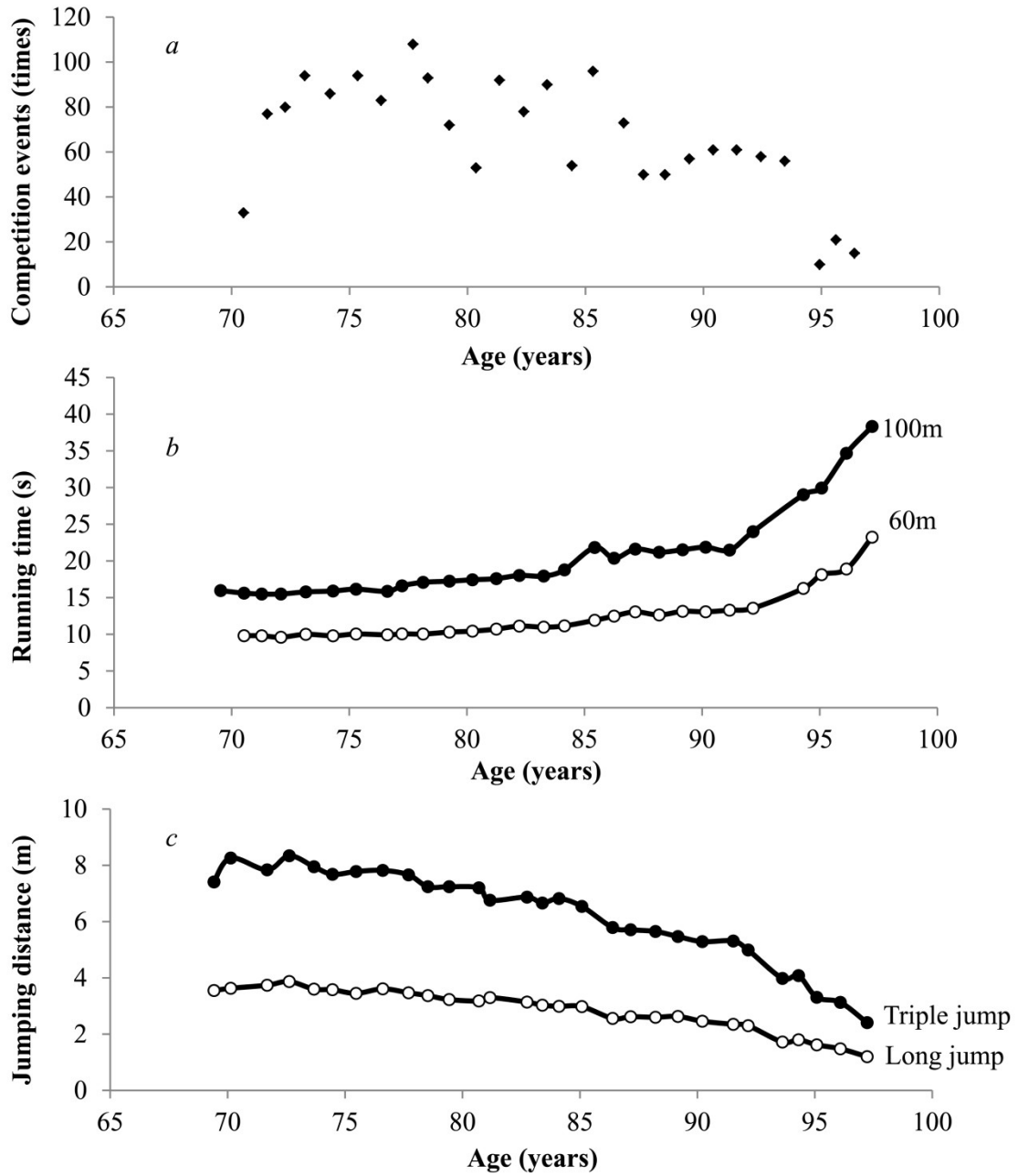
315

316

317

318

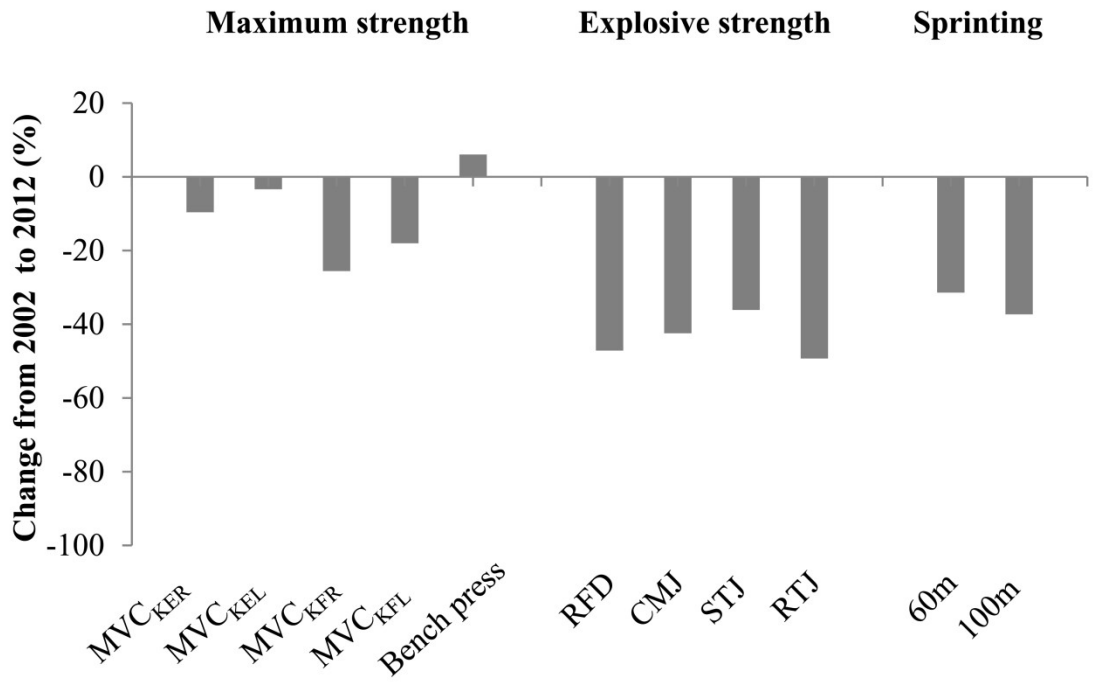
319 **Figure 2.**



320  
 321  
 322  
 323  
 324  
 325  
 326  
 327

**Figure 3.**





328

329

330

331

332