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Influence of Instability and Muscular Weakness in Ethiopathogenesis of Hip Fractures

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A B S T R A C T

The aim of our study was to, in accordance with the presented theoretical presumptions, analyze the possible reasons for hip fractures of the older population in the north-eastern part of Croatia. A group of 2,696 persons (1,936 women and 760 men) with hip fractures has been analyzed during a 12 year period (from 1993. until 2005. year) in the Clinical Hospital Osijek. The date of admittance, age, gender and fracture location were recorded. In men, the incidence of total hip fracture number on the left side was greater 23.5% ($p<0.01$) compared to the right side, while in women this difference does not exist. Men have a greater incidence of trochanteric fractures than fractures of femoral neck on both sides, while in women this difference could be shown on the right side only. In women, a 30.5% ($p<0.001$) higher fracture incidence occurred in the winter compared to the summer. It has been concluded that in men the impaired neuromuscular function on the left body side caused the greater incidence of falls on this side. The more frequent multifragmental fractures of the trochanteric massive in men indicate the possible role of preserved pelvitrochanteric muscle tension in fracture characterization. Increased incidence of falls and fractures in the older female population can be interpreted with a more pronounced weakness of pelvitrochanteric muscles and consequent walking instability. Furthermore, a smaller incidence of hip fractures was noticed in the summer compared with winter. This is explained by a reduced exhaustion of pelvic muscles in summer (primarily pelvitrochanteric) and decrease in fall frequency.

***Key words**: bone, hip fractures, instability, osteoporosis, seasonal variations*

Introduction

Upper femoral fractures are, and will always be, a distinctive part of trauma in older people[1,2]. This kind of injury occurs more frequently in women than in men[3,4], and displays an exponential rise with age[5,6]. The treatment and accommodation of these injuries imposes significant investments to the community[7,8]. The epidemiological studies show an increase of people aged over 65 years[9]. In ethiopathogenesis of hip fractures, as the outlined factors are cited osteoporotic and weak bones of older people, especially women[10,11]. The bone loss with increasing age is partially the effect of the accompanying biochemical changes like: lowering of serum sexual hormones[12,13] and of 25-OH-cholecalciferol levels[14] and an increase of parathyroid hormone concentration[15]. Bone mass loss is more rapid in diabetics[16], chronic alcoholics[17], cigarette smokers[18] and others.

Some authors indicate a low correlation between hip fractures and bone mass, and point out the critical role of instability in falls of older people[19,20]. Frequent falls and walking instability of older people may be the consequence of decreased physical activity and weakness, as well as bone and muscle diseases[21,22]. The fear of falling and of injury in older people may result in a further reduction of physical activity. Some articles indicate that more active older people experience a lesser incidence of lower extremity fractures[23,24], as well as decreased fall frequency[21,25].

Muscular weakness and polyneuropathic difficulties are clinically well known in diabetics and chronic alcoholics[26], which comprised a marked fraction of patients with hip fracture. It is also known that after recovery

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from cerebrovascular insults, due to the remaining peripheral neurological defects, falls as well as hip fractures are more frequent, and that falls are located mainly on the body side with neurological defects[27,28]. A certain number of works indicate the anatomical differences in the structure of the upper part of the femur as a possible reason for the more frequent fractures[29].

Materials and Methods

Patients

Clinical Hospital Osijek, with its Department of Traumatology, is located in the north-east part of Croatia, with typical continental climate. Injured persons with hip fractures comprise a significant number of patients, admitted each day. Only a small number are not hospitalized (those with femoral neck fractures and clear contraindications for operation, or people who are judged, according to their general condition, as incapable to undergo the operation). This minority of injured patients are sent to home care after adequate plaster immobilization. The bulk of patients are treated operatively 2–3 days after reception, following preoperative care.

In our investigation, a group of 2,696 men and women with hip fractures, hospitalized during the 12 year period from 1993. to 2005. has been analyzed. Recorded were the date of admittance, age, gender, fracture location and accompanying chronic diseases like diabetes and peripheral neurological defects of the lower extremities. In our analysis those injured in traffic accidents, children, pathological fractures, and falls which were not in the level have not been included.

Our clinical experience shows that patients with hip fractures are mainly from the older population, and were injured while performing their usual everyday activities. In women with hip fractures, physical weakness, which is not compatible with age, is frequently noticed. Chronic diseases diagnosed in injured patients included diabetes, arterial hypertension, peripheral neurological disorders, chronic bronchitis, trouble with vision, and, rarely, hyperparathyroidism. In men with the same injury, in addition to the diseases already cited, chronic alcoholism is frequently found. Generally, our impression is that the population with hip fractures consists of people with a lower living standard, some of them displaying the syndrome of *dementia senile*.

Trochanteric, subtrochanteric and neck lateral part fractures were treated by stabilization. In the cases of medial neck fractures, where healing could not be accomplished due to abruption of blood supply, we performed arthroplasty. Our operative techniques and indications do not differ from those found in the literature. Postoperative hospital treatment lasted slightly more than two weeks. Physical rehabilitation in old people was more successful in the patients with hip arthroplasty. In the postoperative course we experienced complications like heart decompensation, bronchopneumonia and, less frequently, pulmonary embolism. After hospital treatment the majority of patients continued with rehabilitation in adequate institutions. The healing of stabilized fractures was followed up in the out-patient clinic. A smaller number of patients with fracture stabilization were hospitalized two years later, for the purpose of extraction of osteosynthetic material. A portion of the operated old persons stopped attending the control inspections during the next year, and we lost the evidence about their actual health status.

Data elaboration

The age of the male and female patients is expressed by mean values. The significance of difference between hip frequencies was calculated by χ^2-test. Differences between groups of interest are expressed in percents. The correlation between hip fracture frequencies and the number of sunny hours is expressed by R-value.

All calculations were performed by Microsoft program Excel.

Results

The mean age of the injured women was 75.5 and men 68.9 years. Total fracture number in women was 1,936, in men 760. In women, total number of hip fractures is similar on both body sides (985 vs. 951, ns) while in men the number of fractures is 23.5% higher on left body side (420 vs. 340, $p<0.01$).

Table 1. presents the frequency of hip fractures in hospitalized patients depending on gender, body side and fracture type. In females, the frequency of trochanteric

TABLE 1
HIP FRACTURE FREQUENCIES IN FEMALES AND MALES, ACCORDING TO THE BODY SIDE AND FRACTURE TYPE

Body side	Gender	Fracture Type			Difference	
		T	N	T + N	T > N (%)	p<
Right	Female	550	435	985	26.4	0.001
	Male	203	137	340	48.2	0.001
Left	Female	503	448	951	12.3	ns
	Male	234	186	420	25.8	0.05

T – trochanteric, N – femoral neck

fractures on the right body side was 26.4 % higher compared to femoral neck fractures ($p<0.001$). Such difference could not be shown on the left body side. In males, a greater frequency of trochanteric compared to femoral neck fractures could be demonstrated on both body sides (on the left side 25.8%, $p<0.05$, on the right side 48.2%, $p<0.001$).

Among the chronic diseases that could influence the frequency of hip fractures, we noticed diabetes and peripheral defects of lower extremities like hemiparesis and hemiplegia (Table 2). Diabetes frequency in analyzed females was 7.2% and males 2.5%. In the group of patients with peripheral neurological defects of lower extremities, hip fracture was located on the affected body side in 81.3%.

TABLE 2
INCIDENCE OF DISEASES ACCOMPANYING HIP FRACTURES

Diabetes			
Females		Males	
Frequency	%	Frequency	%
139	7.2	19	2.5
Neurological defects of lower extremities			
On the fractured extremity		On the extremity without fracture	
Frequency	%	Frequency	%
122	81.3	28	18.7

The hip fracture frequency in each month of the 12 years period is compared with the number of sunny hours. The correlation of hip fracture frequency and number of sunny hours is outlined in Table 3. The negative correlation is highest for all fractures in both gender ($R = –0.757$, $p<0.01$), slightly smaller in females ($R = –0.6829$, $p<0.05$), while in males no correlation can be proved ($R = –0.455$, ns).

TABLE 3
CORRELATION OF THE NUMBER OF SUNNY HOURS WITH HIP FRACTURE FREQUENCY IN WOMEN, MEN AND BOTH GENDERS TOGETHER, EXPRESSED BY COEFFICIENT OF CORRELATION, R, AND ITS STATISTICAL SIGNIFICANCE, p.

Patients	R	p<
Women + Men	–0.757	0.01
Women	–0.683	0.05
Men	–0.455	ns

Mean values of number of sunny hours and hip fracture frequency in each month of the time period analyzed are presented in Figure 1.

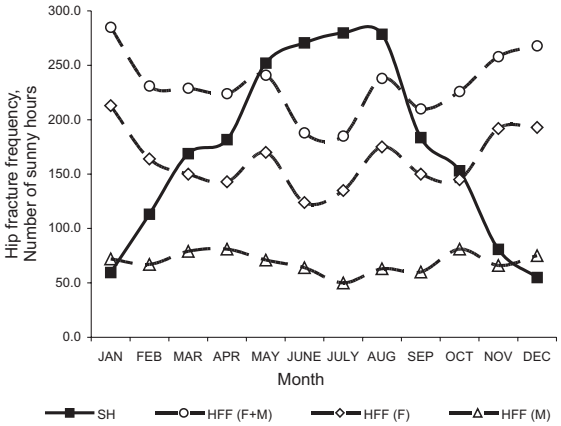

Fig. 1. Number of sunny hours (SH) and hip fracture frequencies (HFF) in females (F), males (M) and both gender (F+M) in each month of the analyzed period.

Further on, fracture frequency in men and women is calculated and compared between the winter (November, December, January and February) and summer (June, July, August and September) period (Table 4). In women, a 30.5% ($p<0.001$) higher fracture incidence in winter is shown, while in men the difference was not significant.

Discussion

The strength of bone tissue is known to be proportional to the bone mass and bone mineral content[30,31]. The loss of bone mass in women starts in postmenopausal period, while in men much later, and it increases almost proportionally with age[32]. The exponential rise of hip fractures with age is hardly possible to explain as a consequence of continuous bone mass loss. If the osteoporosis and weak bones were the only reason of hip fractures, affected women should be younger than affected men. However, we showed that the men with hip fractures are 6.6 years younger than affected women.

TABLE 4
HIP FRACTURE FREQUENCY IN FEMALES AND MALES COMPARED WITH THE NUMBER OF SUNNY HOURS IN WINTER (NOVEMBER, DECEMBER, JANUARY AND FEBRUARY) AND SUMMER (JUNE, JULY, AUGUST AND SEPTEMBER) PERIODS

		Winter	Summer	Difference	
				%	p<
Hip fractures	Females	762	582	30.5	0.001
	Males	275	238	15.6	ns
Number of sunny hours		3,498	11,169	219	0.001

Moreover, if osteoporosis attacks equally both sides of pelvis and consequently both right and left femurs, similar frequency of hip fractures on both body sides should be anticipated. On the contrary, in our group of 760 males, the fractures of the left hip are more frequent (23.5%, $p<0,01$).

To better discuss our results, it is necessary to point out some fundamentals of hip and pelvis biomechanics. Pelvic balance in horizontal position of a walking person is achieved by pelvitrochanteric muscles. The demands on these muscles of the walking old people are not small. Furthermore, in the most people, the more refined movements are always performed by the right (more skilled) foot. Also, great majority of people are right – handed (or »footed«). In most persons, the supporting foot is the left one (i.e. jumping persons in athletics). Of course, it does not mean that the left foot is weaker, or that the pelvitrochanteric muscles on the left side get more quickly tired. In other words, the more frequent fractures of the left hip in our males occur on the less skilled, and, the most probably, on the stronger foot. Our conclusion is that the more frequent left hip fractures in men, can be a consequence of the instability, caused by the weaker neuromuscular function on the left body side.

This presumption is additionally encouraged by our other observations. Out of 2,696 injured persons with hip fractures, 150 displayed peripheral neurological defects on the lower extremities. In 81% of them, the fracture was located on the side with the worse neuromuscular function (Table 2). In addition, several authors showed that persons with neurological defects have a greater incidence of falls, and, consequently, hip fractures, and that these fractures are predominantly located on the diseased side[27,28].

In women, the fracture frequency was similar on both body sides, which can be interpreted by a minor role of weaker neuromuscular function, but a greater exhaustion of pelvic muscles, and, consequently, greater fall incidence. We also demonstrated a high incidence of diabetes in women (7.2%) and men (2.5%) with hip fractures (Table 2). In the literature, the evidence about the quicker loss of bone mass[16] and significant muscular weakness and polyneuropathic difficulties in diabetics[26] can be found.

In most patients (apart from the fractures on the left body side in women) we found the greater incidence of trochanteric fractures, compared to the neck femoral fractures. Such fractures are often multifragmental. It is well known that trochanteric part of pelvis serves as the insertion of the strong pelvitrochanteric muscles. Multifragmental fractures of the trochanteric massive in the region of pelvitrochanteric muscle insertions indicate the possible role of their tension in the fracture characterization.

Analyzing the periodicity of hip fractures, we showed that women exhibit a 30.5% ($p<0.001$) higher incidence of fracturing in winter, compared to summer period (Figure 1, Table 4). This difference could not be shown in men. Also, a negative correlation could be established between the number of sunny hours and hip fracture incidence in our female patients for the whole analyzed period ($R = –0.68288$, $p<0.05$, Table 3), while such correlation could not be proved for male patients. Similar observations on the seasonal variations of hip fractures reported other authors[19]. It is evident that in the conditions of typical continental climate in our region, the number of sunny hours in summer months is more than three times as high, compared to winter months (Table 3). Consequently, in the summer period, with higher ultraviolet radiation, more intensive 7-dehydrocholesterole synthesis[33] and higher D-vitamin concentrations in old people[34], we observed less hip fracture incidence in old women, despite their more intensive physical activity in the summer. Well known is the efficiency of D-vitamin in the expression of muscle activity[35,36]. Similarly, D-vitamin therapy provides successful prevention of falls in older people[37,38]. We can conclude that during the summer period (when physical activity is generally more intensive) the pelvic muscles of old women have a lower tendency to get tired, and therefore in this part of the year, walking becomes more stabile. Seasonal variations of bone mass seem less likely to be the cause of the variations in hip fractures because seasonal bone mass changes do not exceed more than 1%. Similar observations, dealing with seasonal variations in hip fracture frequency, have been reported earlier[39].

Conclusion

General conclusion is that in our patients (independently of gender) hip fractures mainly occur as a consequence of increased instability.

In men, instability is predominantly caused by an impaired neuromuscular function on the left body side; in women, the main reason of instability seems to be weaker pelvitrochanteric muscles.

REFERENCES

COOPER, C., G. CAMPION, LJ. MELTON III, Osteoporosis Int., 2 (1992) 285. — 2. GULLBER, B., O. JOHNELL, J. A. KANIS, Osteoporosis Int., 7 (1997) 407. — 3. JONES, G., T. NGUYEN, P. N. SAMBROOK, P. J. KELLY, C. GILBERT, J. A. EISMAN, Osteoporosis Int., 4 (1994) 277. — 4. BILEZIKIAN, J. P, J. Clin. Endocrinol. Metab., 84 (1999) 3431. — 5. LEWIS, A. F., B.M.J., 283 (1981) 1217. — 6. O'LOUGHLIN, J. L., Y. ROBITAILLE, J. F. BOIVIN, S. Suissa, Am. J. Epidemiol., 137 (1993) 342. — 7. KANIS, J. A., F. BORGSTROM, N. ZETHRAEUS, O. JOHNELL, A. ODEN, B. JÖNSSON, Bone, 36 (2005) 22. — 8. DOLAN, P., D. J. TORGESON, Osteoporosis Int., 8 (1998) 611. — 9. World Population Ageing: 1950–2050, ST/ESA/Ser.A/207, United Nations Publications, Department of Economic and School Affairs, Population Division, United Nations, New York, 2001, accessed 2.5.2006. Available from URL: Http://www.un.org/esa/population/publications/worldageing19502050/index.htm. — 10. CUMMINGS, S. R., D. M. BLACK, M. C. NEVITT, W. BROWNER, J. CAULEY, K. ENSRUD, H. K. GENANT, L. PALERMO, J. SCOTT, T. M. VOGT, Lancet, 341 (1993) 72. — 11. RISS, B. J., M. A. HANSEN, A. M. JENSEN, K. OVERGAARD, C. CHRISTIANSEN, Bone, 19 (1996) 9. —

12. GRAY, A., H. A. FELDMAN, J. B. MCKINLAY, Q. LONGCOPE, J. Clin. Endocrinol. Metab., 73 (1991) 1016. — 13. CENTER, J. R., T. V. NGUYEN, P. N. SAMBROOK, J. A. EISMAN, J. Clin. Endocrinol. Metab., 84 (1999) 3626. — 14. ORWOLL E, S., D. E. MEIER, J. Clin. Endocrinol. Metab., 63 (1986) 1262 — 15. ENDERS, D. B., C. H. MORGAN, P. J. GARRY, J. L. OMDAHL, J. Clin. Endocrinol. Metab., 65 (1987) 724. — 16. SCHWARTZ, A. N., D. E. SELLMEYER, E. S. STROTMEYER, F. A. TYLAVSKY, K. R. FEINGOLD, H. E. RESNICK, R. I. SHORR, M. C. NEVITT, D. M. BLACK, J. A. CAULEY, S. R. CUMMINGS, T. B. HARRIS, J. B. M. R., 20 (2005) 596. — 17. KIM, M. J., M. S. SHIM, M. K. KIM, Y. LEE, Y. G. SHIN, C. H. CHUNG, S. O. KWON, Korean J. Internal Med., 18 (2003) 174. — 18. NGUYEN, T. V, P. J. KELLY, P. N. SAMBROOK, C. GILBERT, N. A. POCOCK, J. A. Eisman, J. Bone Miner. Res., 9 (1994) 1339. — 19. AOYAGI, K., P. D. ROSS, J. W. DAVIS, R. D. WASNICH, T. HAYASHI, T. I. TAKEMOTO, J. Bone Miner. Res, 13 (1998) 1468. — 20. KAPTOGE, S., L. I. BENEVOLENSKAYA, A. K. GHALLA, J. B. Cannata, S. BOVEN, J. A. FALCH, D. FELSENBERG, J. D. FINN, R. NUTI, K. HOSZOWSKI, R. LORENC, T. MIAZGOWSKI, I. JAJIC, G. LYRITIS, P. MASARYK, M. NAVES-DIAZ, G. POOR, D. M. REID, C. SCHEIDT-NAVE, J. J. STEPAN, C. J. TODD, K. WEBER, A. D. WOOLF, D. K. ROY, M. LUNT, S. R. PYE, T. W. O'NEILL, A. J. SILMAN, J. REEVE, Bone, 36 (2005) 387. — 21. WICHAM, C., C. COOPER, B. M. MARGETTS, D. J. BARKER, Age Ageing, 18 (1989) 47. — 22. CAMPBELL, A. J., J. REINKEL, B. C. ALLAN, G. S. MARTINEZ, Age Ageing, 10 (1981) 264. — 23. JOAKIMSEN, R. M., V. FØNNEBØ, J. H. MAGNUS, J. STØRMER, A. TOLLAN, A. J. SØGAARD, J. Bone Miner. Res., 13 (1998) 1149. — 24. FARAHMAND, B. Y., P. G. PERSSON, K. MICHAËLSSON, J. A. BARON, A. ALBERTS, T. MORADI, S. LJUNGHALL, Int. J. Epidemiol., 29 (2000) 308. — 25. GARDNER, M. M., M. C. ROBERTSON, A. J. CAMPBELL, Br. J. Sports Med., 34 (2000)7. — 28. MORGAN, R. O., B. A. VIRNIG, M. DUQUE, E. ABDEL-MOTY, C. A. DE VITO., J. Gerontol., 59 (2004) 1062. — 26. SCHWARTZ, A. V., T. A. HILLIER, D. E. SELMEYER, H. E. RESNICK, E. GREGG, K. E. ENSRUD, P. J. SCHREINER, K. L. MARGOLIS, J. A. CAULY, M. C. NEVITT, D. M. BLACK, J. R. CUMMINGS, Diabetes Care, 25 (2002) 1749. — 27. RAMNEMARK A., L. NYBERG, B. BORSSEN, T. OLSSON, Y. GUSTAFSON, Osteoporosis Int., 8 (1998) 92. — 28. POPLINGHER, A. R., T. PILLAR, Acta. Orthop. Scand., 56 (1985) 226. — 29. NAKAMURA, T., C. H. TURNER, T. YOSHIKAWA, C. W. SLEMENDA, M. PEACOCK, D. B. BURR, Y. IZUNO, H. ORIMO, Y. OUCHI, C. C. JOHNSTON JR, J. Bone Miner. Res., 9 (1994) 1071. — 30. BECK T, J., B. R. CHRISTOPHER, K. E. WARDEN, W. W. SCOTT, G. U. RAO, Invest. Radiol., 25 (1990) 6. — 31. LOTZ, J. C., T. N. GERHARD, W. C. HAYES, J. Comput. Assist. Tomo., 14 (1990) 107. — 32. MELTON, LJ. III, E. J. ATKINSON, M. K. O'CONNOR, W. M. O'FALLON, B. L. RIGGS, J. Bone Miner. Res., 15 (2000) 24. — 33. BOWMAN, W. C., M. J. RAND, The Endocrine System and Drugs Affecting Endocrine Function. In: Textbook of Pharmacology, (Blackwell Scientific Publications, Oxford, 1982) — 34. LIPS, P., F. C. GINKEL, M. J. JONGEN, F. RUBERTUS, W. J. VAN DER VIJGH, J. C. NETELENBOS, Am. J. Clin. Nutr., 46 (1987) 1005. — 35. BIRGE, S. J., J. G. HADDAD, Med. Biol., 56 (1978) 209. — 36. SJÖSTRÖM, M., R. LORENTZON, S. E. LARSSON, D. HOLMLUND, Med. Biol., 56 (1978) 209. — 37. BISCHOFF-FERRARI, H. A., B. DAWSON-HUGHES, W. C. WILLETT, H. B. STAEHELIN, M. BAZEMORE, R. Y. ZEE, J. B. WONG, JAMA, 291 (2004) 1999. — 38. BISHOFF-FERRARI, H. A., W. C. WILLETT, J. B. WONG, E. GIOVANNUCCI, T. DIETRICH, B. DAWSON-HUGHES, JAMA, 293 (2005) 2257. — 39. HAS, B., E. HASSCHÖN, Liječ. Vjesn., 111 (1989) 9.

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ULOGA NESTABILNOSTI I MIŠIĆNE SLABOSTI U ETIOPATOGENEZI PRIJELOMA KUKA

S A Ž E T A K

Analizirana je grupa od 2,696 ozljeđenika (1,936 žena i 760 muškaraca) s prijelomom kuka koji su hospitalizirani u Kliničkoj bolnici u Osijeku tijekom posljednih 12 godina. Navedeni su podaci o datumu prijeloma, dobi, spolu i mjestu prijeloma. U muškaraca je učestalost prijeloma lijevoga kuka češća za 23% ($p<0,01$) u odnosu na desni, a takova razlika se nije našla u traumatiziranih žena sa istovrsnom ozljedom. U muškaraca je obostrano uočena veća učestalost prijeloma trohanteričnih masiva u odnosu na vrat bedrene kosti. U žena se takova razlika uočila samo na desnoj strani. U grupi analiziranih žena postoji veća učestalost prijeloma kuka u zimskom periodu za 30.5% ($p<0,001$) u odnosu na ljetni period. Zaključili smo da su u muškaraca češći padovi i lomovi na strani tijela s lošijom neuromuskularnom funkcijom. Drugim riječima, ukazuje su na ulogu nestabilnosti u etiopatogenezi padova i prijeloma kuka muškaraca starije dobi. Česti višekomadni prijelomi trohanteričnog masiva u muškaraca ukazuju na moguću ulogu očuvanoga mišićnog vlaka pelvitrohanterne muskulature u ispoljavanju karakteristika prijeloma. U žena, povećana učestalost padova i prijeloma kuka starije životne dobi može se prije tumačiti izraženom slabošću pelvitrohanterne muskulature, a posljedično tome i nestabilnošću pri hodu. Također je uočena i izrazito visoka učestalost dijabetesa (7.2%) u grupi od 1,936 analiziranih žena. U klinici su poznate posljedice dijabetesa u ispoljavanju mišićne slabosti i polineuropatskih poteškoća. Nadalje, pokazana je manja učestalost prijeloma u žena tijekom ljeta u odnosu na zimski period. Manja učestalost prijeloma kuka ljeti u starih žena može se tumačiti manjim zamorom mišića (u prvom redu pelvitrohanterne muskulature) i manjom učestalošću padova.