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Feline high-rise syndrome: 119 cases (1998–2001)

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Summary High-rise syndrome was diagnosed in 119 cats over a 4-year period. 59.6% of cats were younger than one year, and the average height of the fall was four stories. High-rise syndrome was more frequent during the warmer period of the year. 96.5% of the presented cats, survived after the fall. 46.2% of cats had fractured limbs; 38.5% of fractures were of the forelimb, 61.5% of the hindlimb. The tibia was fractured most often (36.4%), followed by the femur (23.6%). 78.6% of femoral fractures were distal. The mean age of patients with femoral fractures was 9.1 months, and with tibial fractures 29.2 months. Thoracic trauma was diagnosed in 33.6% of cats. Pneumothorax was diagnosed in 20% of cats, and pulmonary contusions in 13.4%. Falls from the seventh or higher stories, are associated with more severe injuries and with a higher incidence of thoracic trauma.

Introduction

High-rise syndrome is the term used in cases of cats falling from balconies or windows of highrise buildings in urban areas, the minimal height of the fall being the second storey. The cause of the fall in most cases is related to play when the animal jumps from the window or over the balcony, when chasing a bird or insect, or slipping whilst walking on the edge of the balcony railing or window. High-rise syndrome has also been described in dogs (Gordon et al., 1993) and humans, when the terms ''high-flyer syndrome'' or ''jumpers syndrome'' are also used (Reynolds et al., 1971; Smith et al., 1975).

Feline high-rise syndrome has been described by several workers (Barth, 1990, Dupre et al., 1995; Flagstad et al., 1998; Papazoglou et al., 2001; Whitney and Mehlhaff, 1987). Some workers have reported that the relationship between the height of fall and the severity of the injuries follows a curvilinear pattern (Flagstad et al., 1998; Papazoglou

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et al., 2001; Whitney and Mehlhaff, 1987), while others argue that the severity of injuries increases linearly with the height of the fall (Dupre et al., 1995).

The object of this study was to statistically evaluate 119 cats with this syndrome admitted during a 4 year period. The cats fell from at least the second storey, all in greater Zagreb. The injuries of all the cats were documented. We wanted to examine any association between the height of the fall, severity of injuries, and the type of injury.

Materials and methods

In the period between January 1, 1998 and December 12, 2001 at the Clinic of Surgery, Orthopaedics and Ophthalmology of the Veterinary Faculty, 119 cats were treated after a fall or jump from a balcony or window, where the owners saw the fall, or where there was a reasonable suspicion that a fall had occurred. Only those cats that fell from the second or higher stories were included. The owners brought the cats for treatment within varying periods of time after the fall (from 30 min to over a month). Each animal was examined, and radiographical, haematological and biochemical examinations were performed depending on the results of the clinical examination. After the diagnosis was made, and in consultation with the owners, conservative or surgical treatment was undertaken in most cases. Some owners requested euthanasia of the animal.

In evaluating the severity of the injuries the following criteria were used:

Contusions, abrasions, wounds, lacerations, pulmonary contusions, haematuria, epistaxis, dental fractures—score: 1.

Limb fractures, limb luxations, hard palate fractures, mandibular fractures, pelvic fractures, temporomandibular joint luxations, haemothorax, pneumothorax, abdominal wall rupture, diaphragmatic rupture, rupture of urinary bladder, vertebral fractures/luxations—score: 2.

If an animal had several injuries, the points for each injury were summed up. For example, if a cat had a fracture of both radius and ulna, the score was 4; if there was a fractured radius and ulna and fractured tibia, the score was 6; if a cat had a limb fracture with some skin contusions on the same limb, the score was $2+1=3$.

The statistical data processing was performed using the programme Statistica, '99 edition, version 5,5, StatSoft, Inc. The programme was also used to make charts. The Student's *t*-test was used for the age comparison between cats with fractured tibia and fractured femur.

Results

During the defined period, 1402 cats were admitted to the clinic, and in 8.5% (119) of them high-rise syndrome was diagnosed. 96.5% (115/119) cats survived after the fall. The mean age of the cats was 1.8 ± 2.2 years ($M\pm SD$) (range, 2.5 months to 10 years). The age of 5 cats was unknown. 59.6% (68/114) of cats were under one year (Fig. 1). 53.8% (64/119) were female, 42.0% (50/119) were male, 3.4% (4/119) were male neutered, and the sex was undetermined in 1 cat (Fig. 2). The mean storey from which the cat fell was 4.0 ± 0.2 (range, 2 to 16). The median was the fourth storey (Fig. 3).

65% (77/119) of cases occurred in the period from April 1 to September 30 (Fig. 4).

Injuries of the cats are listed in Table 1. In 6 cats euthanasia was carried out; in 2 cases because of the poor prognosis (vertebral fractures/luxations), and in 4 cases because of the cost of treatment. Of the remaining 113 cats, 4 died within the first 36 h following the fall (3.5%). The age range of the cats that died was between 8 months and 5 years, and the fall occurred from between the second and the ninth storey.

46.2% (55/119) of cats had fractures of limbs, excluding pelvic fractures. The mean age of patients with fractures was 1.8 ± 2.1 years. Multiple metacarpal or metatarsal bone fractures of the same limb were counted as 1 fracture. A single fracture of the forelimb was found in 18 cats, and a single fracture of the hindlimb was found in 28 cats. That is, 83.6% (46/55) of the cats had only one fracture. The other 9 cats had multiple fractures. So, 55 cats had 65 fractures. Of 65 fractures, 38.5% (25/65) were in the forelimb, while 61.5% (40/65) were in the hindlimb.

The tibia was the most frequently fractured bone (20 cats), and two cats had fractures of both tibia. Thus 22 of a total of 65 fractures (33.8%) were tibial. The femur was the next most frequently fractured bone, comprising 21.5% (14/65) of all fractures. 13 cats had femoral fractures as one had fractures of both femurs. Of the 14 fractures, 78.6% (11/14) were in the distal bone, and of these 82% (9/11) were distal physeal fractures (these fractures occurred in immature animals). The mean age of the patients with fractured femur was 9.1 ± 6.3 months, while the mean age of the

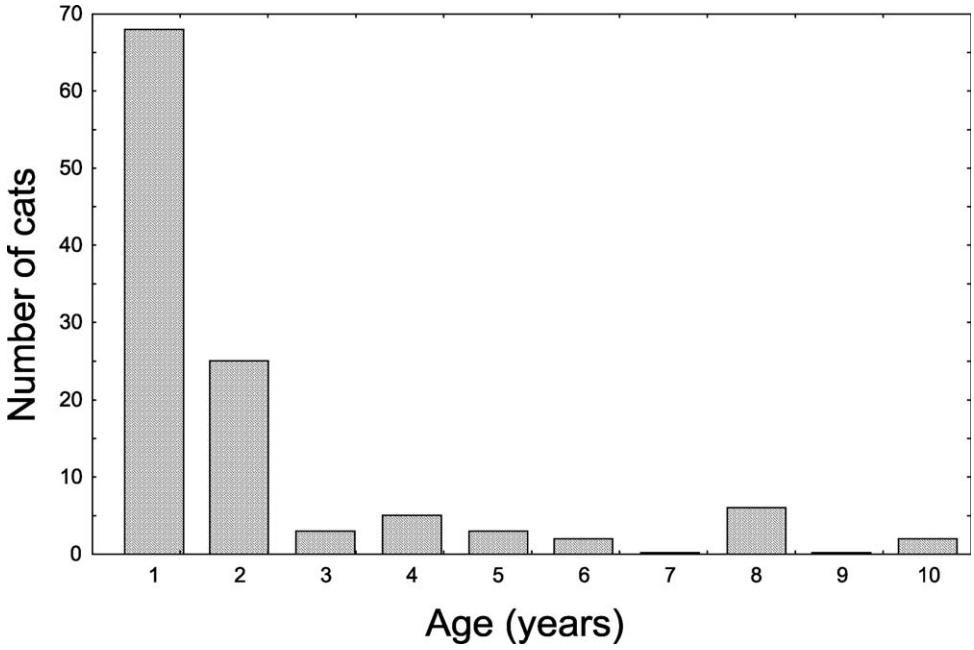

Figure 1 Age distribution of cats with high-rise syndrome.

patients with fractured tibia was 29.2±30.7 months.

In the forelimb, the humerus was fractured in 8 cats and the radius and ulna in 8 cats. Open fractures were recorded in four cats, all of the tibia.

In 30 cats, surgical repair was performed, whilst in 25 cats fractures were treated conservatively either because it was the most appropriate, or because the cost of surgery was prohibitive. In 3 cats luxation was diagnosed; one case of coxofemoral and 2 cases of talocrural luxation. The coxofemoral luxation was treated by closed reduction, and the talocrural luxations were managed surgically.

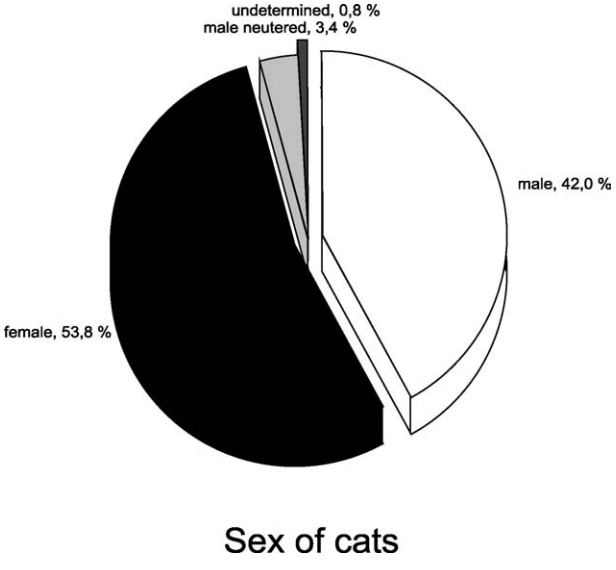

Figure 2 Sex distribution of cats with high-rise syndrome.

9% (11/119) of cats had pelvic fractures, all of which were treated conservatively. In 3 cats vertebral fracture/luxation was present—in one cat the thoracic column was injured, in two cats the lumbar spine was injured. Of those three cats, one died, and two were euthanized.

Fractures of the mandible were diagnosed in 4 cats, and all were fractures of the symphisis. These fractures were stabilized with cerclage wire. Hard palate fractures were recorded in 6 cats. These were repaired by suturing the mucous membrane of the hard palate. In one cat we recorded temporomandibular joint ankylosis—the owner brought the animal to the clinic one month after the fall because the cat could not open its mouth.

In two cats a diaphragmatic rupture was diagnosed. In one cat urine was aspirated during abdominocentesis and during an exploratory laparotomy rupture of the bladder was confirmed. Traumatic abdominal rupture was recorded in two cats. Repair of the rupture was performed between the 3rd and the 5th day after trauma. In 5% (6/119) of cats a perineal wound was found.

In cats with abnormal respiration (a rapid respiratory rate) and tachycardia, decreased respiratory sounds and possible cyanosis, thoracic radiography was carried out. Thoracic trauma was diagnosed in 33.6% (40/119) of cats. Pneumothorax was present in 60% (24/40) of these cats. Pulmonary contusions were diagnosed in 40% (16/40) of cats with thoracic trauma, and haemothorax in

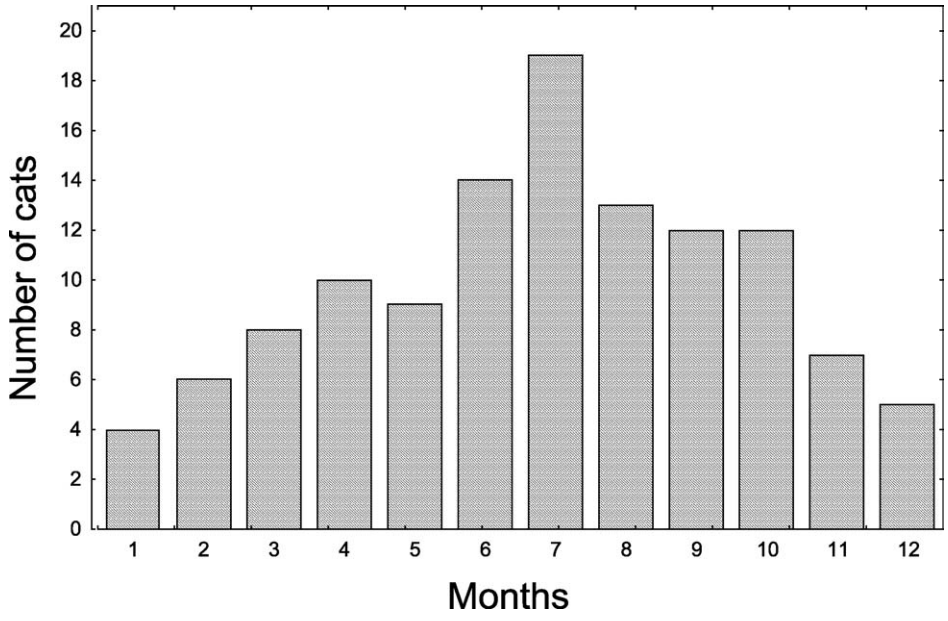

Figure 3 Monthly incidence of high-rise syndrome.

10% (4/40) of cats. Haemothorax was diagnosed by thoracentesis, after the thoracic radiographs had shown the presence of fluid. Thoracentesis was carried out in 8 cats. Epistaxis was found in 8.4% (10/119) of cats.

Shock was diagnosed in 10.9% (13/119) of cats. The shock state was recognized by clinical evaluation. The clinical signs of the shock syndrome were: increased heart rate, weak pulse quality, pale mucous membrane, prolonged capillary refill time, increased respiratory rate and decreased core and peripheral temperature. Shock was treated with intravenous fluids and corticosteroids.

The cats that fell from the second storey had an average injury score 1.98 ± 0.92, those which fell from the third storey 2.71 ± 1.23, from the fourth 2.70 ± 1.31, from the fifth 2.52 ± 1.28, from the sixth 2.62 ± 1.06, and from the seventh and higher stories 3.50 ± 2.27 (Fig. 5).

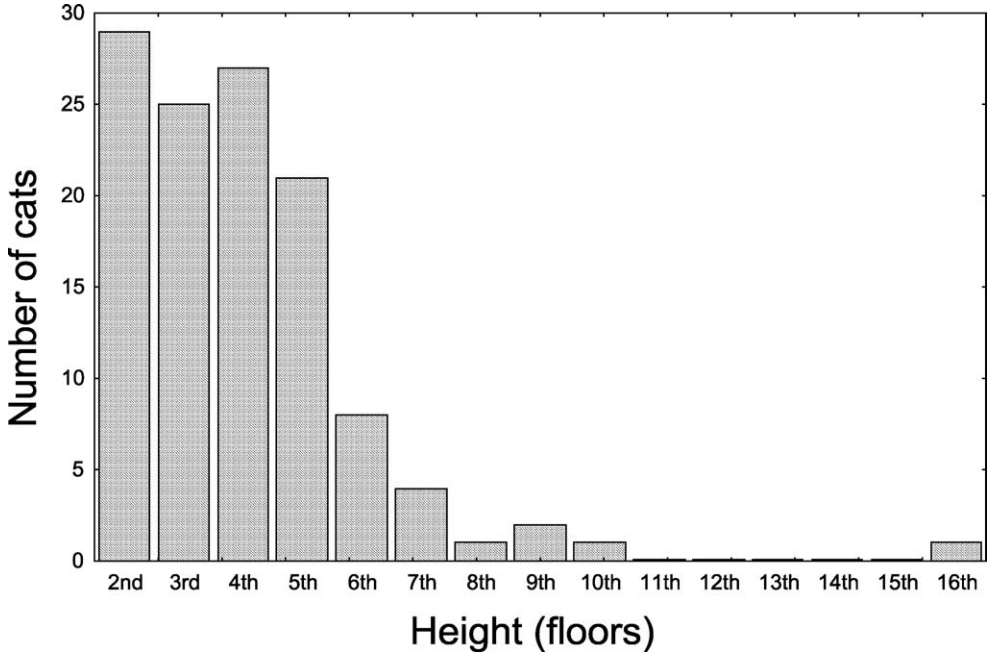

Figure 4 Histogram showing number of cats falling from different heights.

Table 1 Results of clinical assesment in 119 cats with high-rise syndrome

Injury	Number of cats
Limb fractures	65
Forelimb	25
Scapula	3
Humerus	8
Radius, ulna	8
Metacarpus	5
Phalangeal fracture	1
Hind limb	40
Closed fractures	36
Open fractures	4
Femur	14
Tibia	22
Metatarsus	3
Talus	1
Open fracture	4
Limb luxations	3
Hip joint	1
Talocrural joint	2
Contusions (not associated with fractures)	28
Facial (including epistaxis)	12
Extremity	8
Truncal	8
Abrasions, wounds, lacerations (not associated with fractures)	11
Facial	1
Extremity	4
Truncal	6
Hard palate fractures	6
Dental fractures	1
Mandibular fractures	4
Pelvic fractures	11
Vertebral fractures/luxations	3
Intervertebral disc protrusion	1
Temporomandibular joint ankylosis	1
Sacroiliac luxations/fractures	3
Rupture of urinary bladder	1
Traumatic abdominal rupture	2
Diaphragmatic rupture	2
Pneumothorax	24
Haemothorax	4
Pulmonary contusion	16
Shock	13

Discussion

High-rise syndrome occurs in urban areas with tall buildings (Barth, 1990; Dupre et al., 1995; Flagstad et al., 1998; Papazoglou et al., 2001; Whitney and Mehlhaff, 1987). High-rise syndrome is seen mostly in younger cats, mainly the result of behavioral differences between younger and older animals. Younger cats fall from balconies and windows whilst playing (chasing a bird, a butterfly, or playing with other kittens), or they slip and fall whilst walking on the window or balcony rim. The mean age of the cats in our study was 1.8 years. 59.6% of cats were under one year. Whitney and Mehlhaff (1987) reported that 65% of cats were under 3 years. The mean age of the cats in our study is lower than that reported by Dupre et al. (1995)—2.5 years, Flagstad et al. (1998)—2.3 years, and Whitney and Mehlhaff (1987)—2.7, but higher compared to the work of Papazoglou et al. (2001), where it was 1.2 years. The mean age of dogs is higher, reported as 3.2 years by Gordon et al. (1993), and in man most falls involve children (Reynolds et al., 1971).

Papazoglou et al. (2001) reported 51% males, 46% females, 1% castrated males, 1% spayed males and 1% unrecorded gender status. Whitney and Mehlhaff (1987)reported 48% males, 48% females and 4% unrecorded gender status. In their studies 23% of the males were castrated and 27% of the females were spayed. In the USA where neutering and spaying are routine, the ratio of castrated and spayed cats with high-rise syndrome is higher. The routine castration and spaying of cats in Croatia is not common. Therefore, some of injuries may be 'sexually motivated'.

The mean fall in our study was four stories. Most cats fell from between the second and the sixth storey (92%). Most buildings in Zagreb are not higher than six stories. Papazoglou et al. (2001) reported mean fall of 3.7 stories, Whitney and Mehlhaff (1987) reported 5.5 stories, and Flagstad et al. (1998) 3.1 stories. In the latter work the average is lower because cats which fell from the first storey were also included. For the dogs, the mean fall is reported as 2.8 stories (Gordon et al., 1993). High-rise syndrome describes traumatic injuries in cats resulting after falls of two or more stories. Only Flagstad et al. (1998) included cats after falls of the first or higher stories. In our study, we have not recorded cats with any serious clinical signs after falls from first storey. Most falls occurr during the warmer months; 65% of cats fell in the period between April 1 and September 30. Papazoglou et al. (2001) reports that 84% of cats fell between March and November. Flagstad et al. (1998) found a correlation between average daily temperature and the number of falls. Cats fall mostly from balconies and open windows and since owners keep windows open during warmer weather, the correlation between increased temperature and increased number of falls is not surprising.

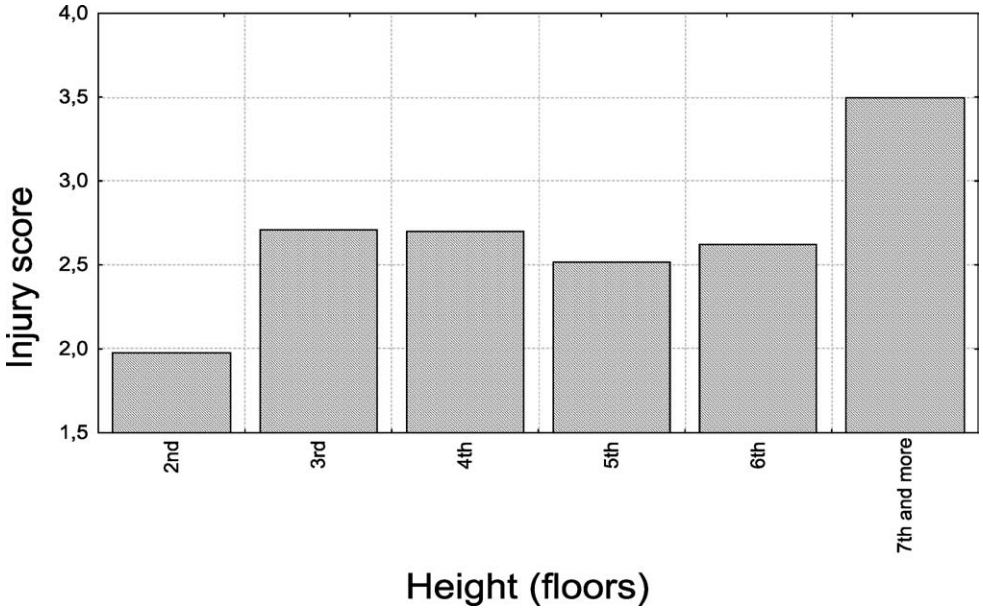

Figure 5 Graph showing the relationship between injury score and height of fall.

Robinson (1976) characterized high-rise syndrome by the following triad of injuries:

1. epistaxis
2. hard palate fracture
3. pneumothorax.

This triad of injuries was found in only 33% of cats in our study. Since, in our study the incidence of limb fractures in the high-rise syndrome cats was significantly higher than the incidence of Robinson's triad, we suggest the inclusion of limb fractures in the injuries which characterize the high-rise syndrome, turning the triad into the high-rise tetralogy.

In our study, epistaxis was found in 8.4% of cats. Papazoglou et al. (2001) reported epistaxis in 2% of cats, Flagstad et al. (1998) in 13.5%, and Barth (1990) in 64.4% of cats.

Hard palate fractures were found in 5% of cats in our study. Papazoglou et al. (2001) reported hard palate fracures in 3% of cats, Flagstad et al. (1998) and Dupre et al. (1995) in 11% and Whitney and Mehlhaff (1987) in 17% of cats.

Thoracic trauma was present in 33.6% of cats. Pneumothorax was diagnosed in 20% of cats, pulmonary contusions in 13.4%, and haemothorax in 3.4%. Barth (1990) found pneumothorax in 62%, and pulmonary contusions in 58% of cats. Whitney and Mehlhaff (1987) diagnosed thoracic trauma in 90% of cats, pulmonary contusions in 68%, and pneumothorax in 63% of cats. Papazoglou et al. (2001) reported thoracic trauma in only 13% of cats, pneumothorax in 4%, and pulmonary contusions in 6.8%. Flagstad et al. (1998) diagnosed pneumothorax in only 7.1% of cats. Whitney and Mehlhaff (1987) recommended thoracic radiography in all cats and thoracic radiography was performed on 69% of the cats. Papazoglou et al. (2001) reported that thoracic radiography was carried out in all cats. The differences between the studies might be explained by different protocols in assessing thoracic trauma. Also, such differences could be explained by the length of time between the fall and the admission to a clinic. Dyspnea and tachypnea may be due to pneumothorax or be the result of shock and acute pain. The breathing pattern may improve with time as acute pain and shock diminish. In this case thoracic trauma may not be suspected and radiography will not be performed. Because in our study, thoracic radiography was only carried out on those cats showing the abnormal respiration, and that may explain why the incidence of thoracic trauma was perhaps significantly lower. Some animals with thoracic trauma may have minimal clinical signs, or even none (Aron and Roberts, 1993). In these animals, possible thoracic trauma was not diagnosed.

In addition to the triad of injuries reported by Robinson (1976), limb fractures are also very common. In our study, 46% of patients had limb fractures. Papazoglou et al. (2001) found fractures in 50% of patients, Whitney and Mehlhaff (1987) in 39%, and Flagstad et al. (1998) in 50% of patients, but they also included pelvic fractures. The lower percentage of limb fractures reported by Whitney and Mehlhaff (1987) may be due to a greater fall height, where the animals are not falling with their extremities extended. In our study, the ratio

between forelimb and hindlimb fractures is 1:1.6. In the study by Papazoglou et al. (2001) this ratio is 1:2, while Whitney and Mehlhaff (1987) and Flagstad et al. (1998) state equal numbers of forelimb and hindlimb fracture. Gordon et al. (1993) reported that forelimb fractures are more common in dogs since dogs initially land on the forelimbs. Femoral fractures in our study were found in 24% of cats with fractures. Papazoglou et al. (2001) diagnosed femoral fractures in 40% of cats with fractures, Whitney and Mehlhaff (1987) in 46%, and Flagstad et al. (1998) in 18%. Whitney and Mehlhaff (1987) found that 93% of patients with femoral fracture were under one year. In our study the tibia was fractured in 36% of cats. All of the four open fractures were at the tibia. In 79% of cats the femur was fractured in its distal part. The mean age of patients with a fractured femur was 9 months, but 29 months in the case of the fractured tibia. This can be explained by the fact that femoral fractures were mainly in distal part, near the growth zone.

Papazoglou et al. (2001) and Whitney and Mehlhaff (1987) excluded pelvic fractures from hindlimb fractures. If 11 pelvic fractures are added to the limb fractures, 33% (25/76) fractures are in the forelimb, and 67% (51/76) are in the hindlimb. With this correction, however, the ratio of hindlimbs fracture was not significantly changed.

The relatively low incidence of abdominal injuries in our study can be explained by the fact that forelimbs absorb most of the impact force at landing.

Papazoglou et al. (2001) suggests the large number of vertebral injuries in their study is due to the fact that most cats fell from below the fifth storey and did not have time to achieve a feet-first landing. Another reason why cats may not land on their feet maybe the various barriers, which they might encounter during the fall (e.g. metal structures for hanging laundry, potted plants on balcony railings, etc.).

Kapatkin and Matthiesen (1991) suggest that the type of injury depends upon the height of the fall and the landing surface. The severity of injuries rises linearly up to the seventh storey. After that height, the severity of injuries does not rise and and the incidence of fractures decreases. Of 22 cats that fell more than seven stories only one died, and among 13 cats that fell more than nine stories only one fracture was diagnosed. One cat that fell 32 stories suffered only mild pneumothorax and a chipped tooth (Whitney and Mehlhaff, 1987). Robinson (1976) stated that the maximum recorded heights for survival were 18 stories on to a hard surface, 20 stories on to shrubbery, and 28 stories on to awning. Gordon et al. (1993) states that dogs cannot survive falls from distances higher than six stories. During free fall, cats have a unique ability to quickly change the position of their body and maintain a feet-first landing position. Cats behave like parachutists, achieving a maximum velocity during free fall. An average-sized cat (4 kg), in a horizontal position, maximizes drag and achieves a maximum velocity of approximately 100 km/h after falling five stories. At the beginning of the fall the cat instinctively extends its limbs and if the impact occurs at that moment the most common injuries are limb fractures. After the maximum velocity has been achieved, the vestibular system is no longer stimulated and the cat orients its limbs horizontally. This horizontal position could explain the decreased number of limb fractures, but since the impact is more evenly distributed throughout the body, the incidence of thoracic injuries increases.

Papazoglou et al. (2001) determined the total number of injuries and only orthopaedic injuries. Whitney and Mehlhaff (1987) determined the total number of injuries, the number of thoracic injuries, the number of fractures and the number of split palates. In our study, the injury score is a sum of injuries. We formed two groups considering the severity of injury.

In our study, the injury score increased with falls from between the second and the third storey, it was variable in falls from the third and the sixth storey, and increased sharply from the seventh storey upwards (Fig. 5). Our findings differ from those of the study by Dupre et al. (1995) where the injury score increased linearly with the height of fall. Flagstad et al. (1998), Whitney and Mehlhaff (1987) and Papazoglou et al. (2001) state that the curve has a curvilinear pattern. Our curve does not reveal any definite pattern. When falling from distances up to the sixth storey, where maximum velocity is not reached, the animal falls with extended limbs, so that the severity of injury does not only depend upon the height, but also on the surface, dexterity of the animal, etc. When falling from the seventh and higher stories, the animal orients its limbs horizontally after achieving maximum velocity so that the impact is more evenly distributed throughout its body. The body hits the surface first, followed by the head. Fig. 6 shows the percentage of cats falling from specific stories in which fractures, thoracic trauma and hard palate fractures were diagnosed. The incidence of fractures decreases with falls from heights above the third storey, while the occurence of thoracic trauma increases sharply with falls of more than six stories. 80% of cats falling from the third storey had fractures of limbs or pelvis, while 80% of cats falling

Figure 6 Graph showing the percentage of cats with particular injuries when falling from different heights.

from the seventh or higher stories suffered thoracic trauma. This substantiates the theory that cats falling at least seven stories flex their limbs so that truncal injuries are more common, while cats falling from distances lower than seven stories extend their limbs, the consequence being a greater incidence of limb fractures.

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