Comparison of morphological, densitometric and mechanical properties of femur, tibia and tarsometatarsus in male ostriches (Struthio camelus)

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Introduction

Rapid growth rate and breeding selection for higher body weight gain in poultry species result in skeletal disorders. Deformities, rotations and fractures of pelvic limb bones occurring in fast growing meat-type birds are related to an insufficient adaptation of skeleton to bear heavy body weight. Ostrich (*Struthio camelus*) is the heaviest poultry species breed for valueable meat products. Thus, weight bearing bones of skeletal system in ostriches may be susceptible to structural and functional disorders. Considering that bone disorders may be associated with many factors including environmental conditions, breeding management errors, genetic factors, improper feeding, antinutritional factors, abnormal collagen synthesis and impaired mineral metabolism in ostriches, the aim of this study was to compare basic morphometric, densitometric and mechanical properties of femur, tibia and tarsometatarsus in healthy male ostriches at slaughter age.

Materials and methods

Ten male ostriches (*N*=10) were kept to slaughter age of 14 months of life to obtain left femur, tibia and tarsometatarsus (TM) for analyses. Final body weight, bone length (L), bone weight (W) and relative bone weight (RBW) were determinied. Using quantitative computed tomography technique (Somatom Emotion, Siemens, Germany), cortical bone mineral density (Cd), mean volumetric bone mineral density (MvBMD), total bone volume (Bvol) and calcium hydroxyapatite density (Ca-HA) in the cortical bone were measured. Areal bone mineral density (BMD) and bone mineral content (BMC) were measured with the use of dual-energy X-ray absorptiometry (DEXA, Norland XR-46 appartus, Fort Atkinson, USA). Geometrical properties such as cortical bone area (CBA), cross-sectional area (A), second moment of inertia (Ix), mean relative wall thickness (MRWT) and cortical index (CI) were derived from the measurements of horizontal and vertical diameters of the investigated bones in the midshaft. Using an INSTRON 3367 apparatus (Instron, USA) and three-point bending test, mechanical parameters such as maximum elastic strength (Wy) and ultimate strength (Wf) of bones were determined. Statistical analysis was performed using one-way ANOVA and post-hoc Duncan's test. *P-value* < 0.05 was considered as statistically significant.

Results

Bone weight, RBW, Bvol, BMD and BMC of tibia were significantly higher when compared to these parameters in femur and tarsometatarsus (P<0.001). Bone length reached the highest value in tibia than in tarsometatarsus and femur (all P<0.001). MvBMD was the highest in tarsometatarsus than in tibia and femur (all P<0.001). Ix reached the highest value in femur than in tibia and tarsometatarsus (all P<0.05). CBA and A were significantly lower in tarsometatarsus than in femur and tibia (P<0.001). MRWT and CI were significantly lower in femur than in tibia and tarsometatarsus (P<0.001). Wy of femur, tibia and tarsometatarsus were not significantly different (P>0.05). Wf of tarsomatatarsus was significantly decreased when compared to femur and tibia P<0.05; Table 1).

Conclusions

This study showed significant differences between morphological, densitometric and mechanical properties of the evaluated bones of pelvic limb in male ostriches. Determination of morphological, densitometric and mechanical properties of femur, tibia and tarsometatarsus in male ostriches may serve as an attractive model for studies on metabolic regulation of skeletal system properties with environmemtal, physiological, dietary, pharmacological and toxicological factors.

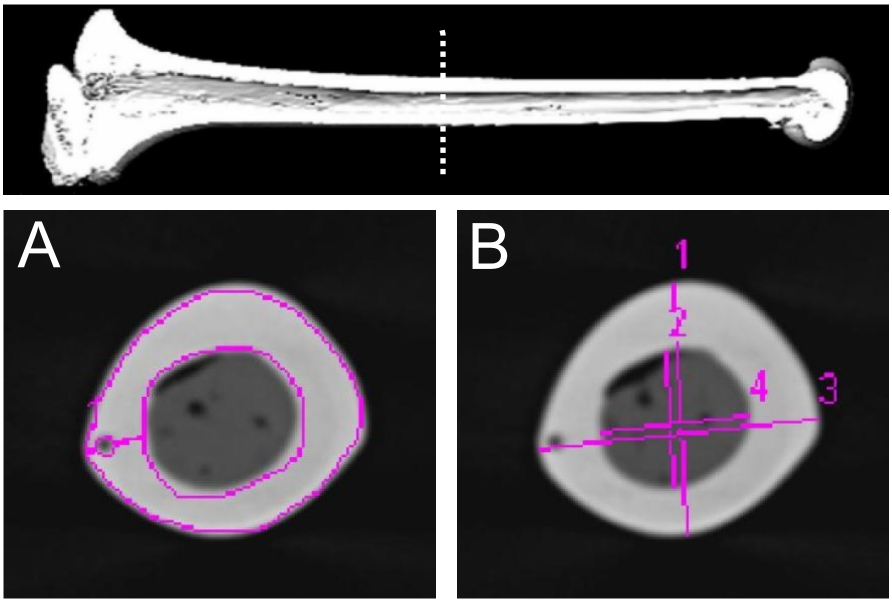

Fig. 1. Three dimensional computed tomography reconstruction of the longitudinal section of the tibia in ostriches (upper panel) and cross-sectional measuring scans (lower panel). The volumetric bone mineral density (vBMD) of tibia was determined using quantitative computed tomography (QCT) technique and 2-mm thick cross-sectional mid-diaphyseal scan (A). The region-of-interest for cortical bone mineral density (Cd) determination was placed at 50% of bone length (A - lower panel) within the space between the continuous lines. The same cross-sectional scan of the midshaft was used to determine horizontal and vertical diameters (both external and internal) of the bone (B - lower panel) to derive geometrical parameters.

Table 1. Morphological, densitometric and mechanical properties of femur, tibia and tarsometatarsus in 14-month-old male ostriches.

Investigated parameter	Femur (N = 10)	Tibia (N = 10)	Tarsometatarsus (N = 10)
Bone weight (g)	626.9 ± 22.6 [a]	1110.7 ± 33.1 [b]	639.8 ± 16.7 [a]
Relative bone weight	0.00663 ± 0.00022 [a]	0.01178 ± 0.00038 [b]	0.00679 ± 0.00020 [a]
Bone length (mm)	303.2 ± 3.0 [a]	537.7 ± 7.5 [b]	473.1 ± 5.5 [c]
Total bone volume (cm^3)	313.2 ± 15.2 [a]	638.4 ± 23.3 [b]	348.3 ± 8.3 [a]
Bone mineral density (g/cm^2)	1.347 ± 0.029 [a]	1.884 ± 0.033 [b]	1.491 ± 0.022 [c]
Bone mineral content (g)	238.4 ± 7.0 [a]	401.3 ± 10.6 [b]	259.3 ± 6.6 [a]
Mean volumetric bone mineral density (g/cm^3)	1.644 ± 0.016 [a]	1.794 ± 0.015 [b]	1.946 ± 0.019 [c]
Cortical bone mineral density (g/cm^3)	2.562 ± 0.046 [a]	2.565 ± 0.029 [a]	2.495 ± 0.026 [a]
Calcium hydroxyapatite density in the cortical bone (mg/ml)	1143 ± 24 [a]	1231 ± 18 [b]	1120 ± 23 [a]
Cortical bone area (mm^2)	521 ± 22 [a]	513 ± 12 [a]	413 ± 10 [b]
Cross-sectional area (mm^2)	560 ± 20 [a]	525 ± 14 [a]	414 ± 9 [b]
Second moment of inertia (mm^4)	133669 ± 6178 [a]	41009 ± 2714 [b]	26537 ± 1038 [c]
Mean relative wall thickness	0.319 ± 0.018 [a]	0.703 ± 0.043 [b]	0.822 ± 0.045 [c]
Cortical index	24.05 ± 1.00 [a]	40.83 ± 1.52 [b]	44.64 ± 1.39 [c]
Maximum elastic strength (N)	7675 ± 582 [a]	7855 ± 503 [a]	6715 ± 280 [a]
Ultimate strength (N)	10165 ± 553 [a]	10433 ± 281 [a]	8818 ± 345 [b]

[abc]Statistically significant differences for $P \leq 0.05$ by one-way ANOVA and post-hoc Duncan's test.