Morphological, densitometric and mechanical properties of femur, tibia and tarsometatarsus in female ostriches (Struthio camelus)

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Introduction

Current genetic selection for higher body weight gain in poultry results in insufficient adaptation of skeleton to heavy body weight. As a consequence of impaired bone adaptation, the skeleton is not able to fulfill its functions in poultry. Ostriches (*Struthio camelus*) are very attractive as the source of high biological value meat products. It is predicted that meat products from ostriches contributing to total meat market will increase consequently during next decades. To avoid skeletal system disorders in ostriches, similar to those observed in meat type chickens and turkeys and resulting from breeding selection for higher growth rate and final body weight, intensive studies on bone peoperties and skeletal system quality should be conducted. Thus, the aim of the study was to investigate morphometric, densitometric and mechanical properties of femur, tibia and tarsometatarsus in female ostriches at slaughter age.

Materials and methods

Thirteen female ostriches (*N*=13) were kept to slaughter age of 14 months of life to obtain left femur, tibia and tarsometatarsus (TM) for analysis. 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 (Figure 1). 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 estimated. 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, BMC and Ca-HA of tibia were significantly higher when compared to these parameters in femur and tarsometatarsus (P<0.01). Bone length and BMD reached the highest values in tibia than in tarsometatarsus and femur (both P<0.01). 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<0.01). Cd, CBA, A and Wy were significantly lower in tarsometatarsus than in femur and tibia (P<0.05). MRWT and CI were significantly lower in femur when compared to tibia and tarsometatarsus (P<0.001). Wf of tarsometatarsus was significantly lower than in tibia (P=0.01; Table 1).

Conclusions

The obtained results have shown significant differences between morphological, densitometric and mechanical properties of the evaluated bones in female ostriches. Determination of morphological, densitometric and mechanical properties of femur, tibia and tarsometatarsus in female ostriches may serve for further studies on metabolic regulation of skeletal system properties with environmemtal, physiological, dietary, pharmacological and toxicological factors.

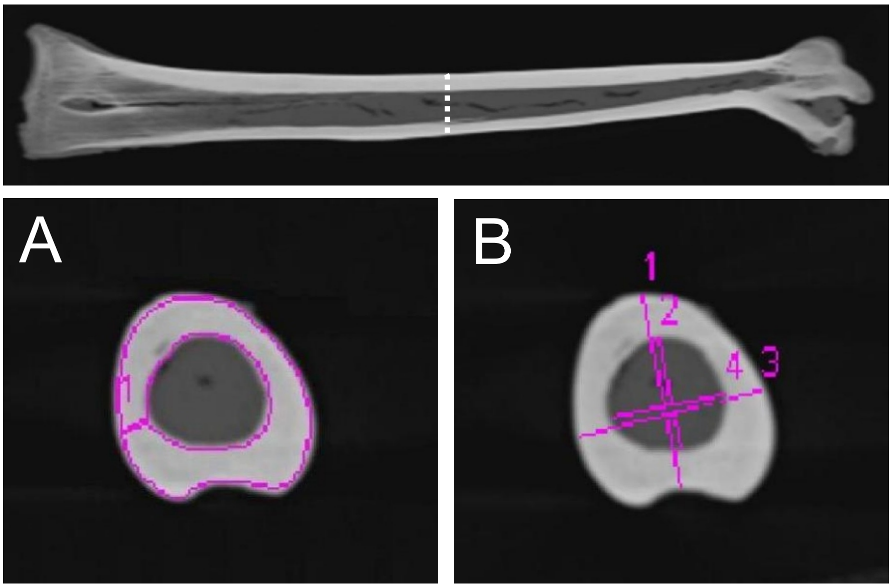

Fig. 1. **Three dimensional computed tomography reconstruction of the longitudinal section of the tarsometatarsus in ostriches (upper panel) and cross-sectional measuring scans (lower panel). The volumetric bone mineral density (vBMD) of tarsometatarsus was determined using quantitative computed tomography (QCT) technique using 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 female ostriches.

Investigated parameter	Femur (N = 13)	Tibia (N = 13)	Tarsometatarsus (N = 13)
Bone weight (g)	571.3 ± 15.4 ^{a}	1004.8 ± 25.6 ^{b}	638.6 ± 24.3 ^{a}
Relative bone weight	0.00611 ± 0.00008 ^{a}	0.01075 ± 0.00011 ^{b}	0.00670 ± 0.00028 ^{a}
Bone length (mm)	298.8 ± 2.4 ^{a}	528.8 ± 5.0 ^{b}	475.4 ± 7.4 ^{c}
Total bone volume (cm^3)	306.0 ± 14.2 ^{a}	587.7 ± 16.0 ^{b}	339.3 ± 10.2 ^{a}
Bone mineral density (g/cm^2)	1.344 ± 0.029 ^{a}	1.845 ± 0.036 ^{b}	1.468 ± 0.034 ^{c}
Bone mineral content (g)	224.1 ± 6.5 ^{a}	371.8 ± 10.2 ^{b}	240.5 ± 7.5 ^{a}
Mean volumetric bone mineral density (g/cm^3)	1.645 ± 0.011 ^{a}	1.798 ± 0.011 ^{b}	1.937 ± 0.020 ^{c}
Cortical bone mineral density (g/cm^3)	2.660 ± 0.020 ^{a}	2.616 ± 0.019 ^{a}	2.530 ± 0.023 ^{b}
Calcium hydroxyapatite density in the cortical bone (mg/ml)	1171 ± 28 ^{a}	1256 ± 19 ^{b}	1121 ± 21 ^{a}
Cortical bone area (mm^2)	465 ± 12 ^{a}	462 ± 12 ^{a}	375 ± 10 ^{b}
Cross-sectional area (mm^2)	516 ± 17 ^{a}	525 ± 16 ^{a}	382 ± 11 ^{b}
Second moment of inertia (mm^4)	117141 ± 5943 ^{a}	36578 ± 2009 ^{b}	23200 ± 1333 ^{c}
Mean relative wall thickness	0.308 ± 0.014 ^{a}	0.752 ± 0.049 ^{b}	0.787 ± 0.041 ^{b}
Cortical index	23.43 ± 0.85 ^{a}	42.29 ± 1.57 ^{b}	43.51 ± 1.35 ^{b}
Maximum elastic strength (N)	7704 ± 403 ^{a}	7793 ± 337 ^{a}	6626 ± 284 ^{b}
Ultimate strength (N)	9312 ± 491 ^{ab}	9851 ± 346 ^{a}	8320 ± 351 ^{b}

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