The Bone Metabolic Response to Dietary Tart Cherry Supplementation in an Animal Model of Postmenopausal Osteoporosis

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Abstract

Osteoporosis is a common cause of pain and disability associated with aging. Previous studies from our lab have shown that supplementing the diet with dried plums, high in phenolic acids, prevents bone loss. This study examined the extent to which tart cherry, another rich source of phenolic compounds, prevents bone loss in an animal model of postmenopausal osteoporosis. Five month old female C57BL/6 mice (n=10/group) were either Sham operated or ovariectomized (OVX) to induce estrogen deficiency and then randomly assign to one of three treatment groups for 28 days: Sham + Control diet (CON), OVX + CON, or OVX + 5% (w/w) cherry diet. Cherry supplementation at 5% did not prevent the OVX-induced decrease in bone mineral density (BMD) and cortical or trabecular bone in the femur, but provided some protection against trabecular bone loss in the lumbar vertebra. Finite element analyses revealed that there was no effect of cherry supplementation on biomechanical parameters within the trabecular bone of the distal femur metaphysis. These data suggest that the effects of low dose cherry supplementation are modest at best in this model and site specific.

Introduction

- Osteoporosis is a musculoskeletal disease that affects approximately 44 million Americans and is characterized by a decrease in bone mass and increased risk of fracture (1-2).
- Women are at greater risk for osteoporosis than men due to the rapid phase of bone loss (i.e., 1-2% per year) that occurs for the first 5-10 years after menopause (1).
- Current FDA-approved treatments can be cost prohibitive and have adverse effects which lead to poor compliance (3). Alternative low-cost, options that could be incorporated into the diet may provide an appealing alternative to current treatment options.
- Our lab has reported that dietary supplementation with dried plum, which is rich in phenolic acids, can prevent bone loss (4-5). The intent of this study was to explore the efficacy of an alternative food, the tart cherry, with a similar phenolic compound profile as the dried plum.
- The purpose of this study was to investigate the extent to which supplementing the diet with a relative low dose tart cherry would prevent bone loss in an animal model of postmenopausal osteoporosis.

Methods

- Five month old, female C57BL/6 mice (n=10/group) were either sham-operated (Sham) or ovariectomized (OVX) and assigned to a control diet (CON=AIN-93M), or CON diet supplemented with 5% tart cherry (w/w) for 28 days.
- Body weights were recorded weekly and at the end of the study a whole body dual-energy x-ray absorptiometry scan (Lunar, PixiMus) was performed to assess bone mineral area (BMA), content (BMC) and density (BMD).
- Micro-computed tomography (MicroCT40, SCANCO Medical, Switzerland) scans were performed on the distal metaphysis of the femur and the sixth lumbar vertebra of the spine to assess trabecular bone microarchitecture: trabecular bone volume (BV/TV), trabecular thickness (TbTh), trabecular number (TbN) and trabecular separation (TbSp).
- Micro-CT scans were also performed on the mid-diaphysis of the femur to assess cortical bone microarchitecture parameters: cortical area, cortical porosity and medullary area.
- Finite element analyses (SCANCO Medical) were performed on 3-dimensional structure generated by the microCT on trabecular bone.
- The data were analyzed using ANOVA (SAS version 9.3), followed by post-hoc analysis with Fisher's least square means separation test when F values were <0.05. Data are presented as mean ± SE ($\alpha < 0.05$).

Results

Table 1. Body Weight, Body Composition and Bone Densitometry

	Sham-CON	OVX-CON	OVX-5% Cherry
Body Weight			
Baseline (g)	20.9 ± 0.2	21.6 ± 0.2	21.7 ± 0.4
Final (g)	21.1 ± 0.4[a]	24.1 ± 0.2[b]	25.1 ± 0.5[b]
Body Composition			
Lean mass (g)	15.94 ± 0.24[a]	17.03 ± 0.30[b]	17.21 ± 0.36[b]
Fat mass (g)	4.76 ± 0.13[a]	6.12 ± 0.22[b]	6.54 ± 0.26[b]
Percent fat (%)	23.0 ± 0.4[a]	26.4 ± 0.5[b]	27.5 ± 0.5[b]
Whole Body			
BMC (g)	0.63 ± 0.01[a]	0.53 ± 0.01[b]	0.52 ± 0.01[b]
BMA (cm^2)	11.58 ± 0.1[a]	10.73 ± 0.1[b]	10.59 ± 0.1[b]
BMD (g/cm^2)	0.054 ± 0.0004[a]	0.049 ± 0.0005[b]	0.049 ± 0.0004[b]

Bone mineral content (BMC); bone mineral area (BMA); bone mineral density (BMD). Values that do not share the same superscript letter within a given row are statistically significantly different from each other, $p < 0.05$.

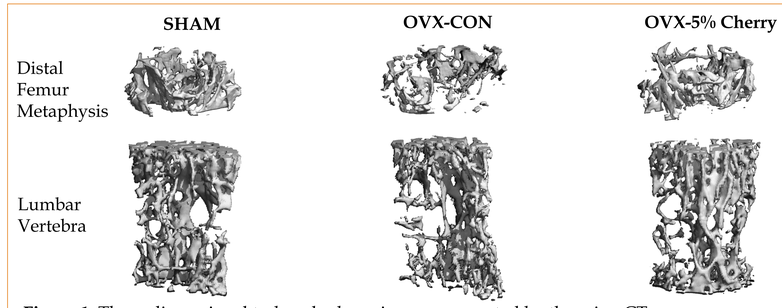

Figure 1. Three-dimensional trabecular bone images generated by the microCT.

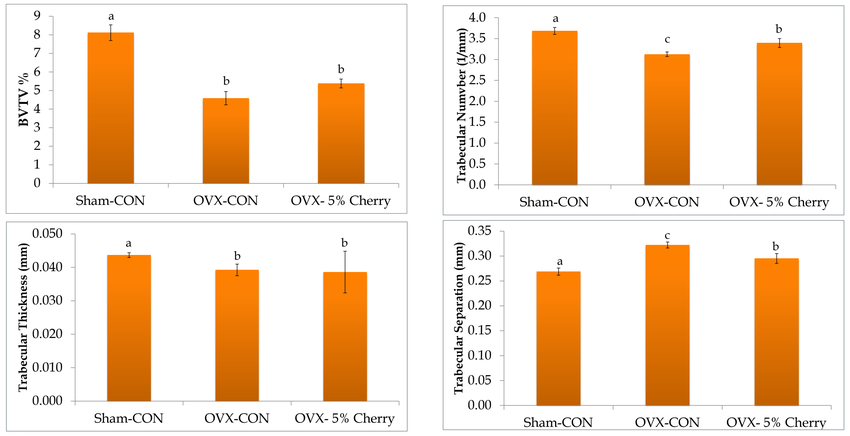

Figure 2. MicroCT analyses of trabecular bone in the femur distal metaphysis. Supplementation with tart cherry (5%) was unable to prevent the OVX-induced decrease in trabecular bone volume (BV/TV), number (TbN) and thickness (TbTh) and increase in trabecular separation (TbSp). Bars that do not share the same superscript are statistically different from each other, $p<0.05$.

Table 2. Cortical Bone Parameters Assessed Using MicroCT

	Sham-CON	OVX-CON	OVX-5% Cherry
Cortical Thickness (mm)	0.204 ± 0.003[a]	0.187 ± 0.002[b]	0.192 ± 0.002[b]
Cortical Area (mm^2)	0.0115 ± 0.002[a]	0.0104 ± 0.0001[b]	0.0107 ± 0.0002[b]
Porosity (%)	0.065 ± 0.012	0.055 ± 0.001	0.064 ± 0.007
Medullary Area (mm^2)	0.059 ± 0.0.013	0.042 ± 0.001	0.051 ± 0.007

Values within a given row that do not share the same superscript letter are statistically significantly different from each other, $p < 0.05$.

Table 3. Biomechanical Testing Using Finite Element Analysis

	Sham-CON	OVX-CON	OVX-5% Cherry
Stiffness (1 x 10^3N/m)	373.0 ± 78.0[a]	132.3 ± 329.1[b]	126.7 ± 2.6[b]
Total Force (N)	0.65 ± 0.14[a]	0.23 ± 0.06[b]	0.22 ± 0.05[b]
Size Ind. Stiffness (N/m)	92.20 ± 19.58[a]	34.09 ± 8.64[b]	39.68 ± 9.66[b]
von Mises Stresses	0.91 ± 0.20[a]	2.10 ± 0.41[b]	2.11 ± 0.38[b]

Finite element analyses performed on the distal femur metaphysis. Values within a given row that do not share the same superscript letter are statistically significantly different from each other, $p < 0.05$.

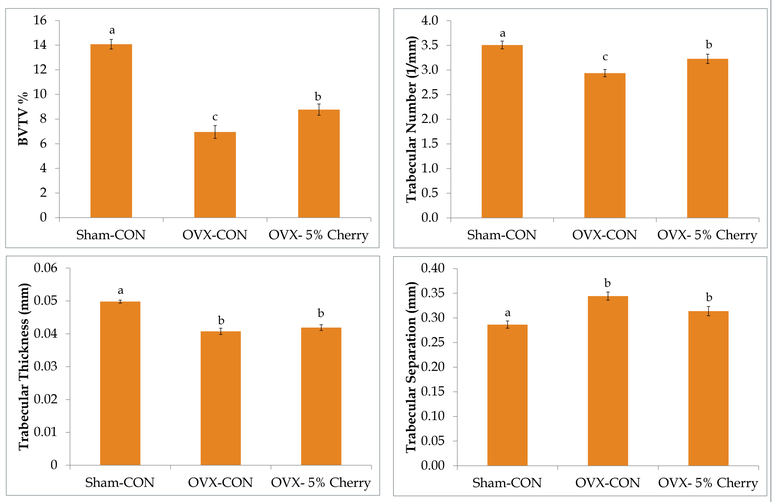

Figure 3. MicroCT analyses of trabecular bone in the lumbar spine. Supplementation with tart cherry (OVX-5% Cherry) provided some protection from the OVX-induced (OVX-CON) decrease in trabecular bone volume (BV/TV) and number (TbN), and increase in trabecular separation (TbSp). Bars that do not share the same superscript letter are statistically different from each other, $p<0.05$.

Summary and Conclusion

- Low dose tart cherry supplementation was not able to prevent weight gain and the negative effects of estrogen deficiency on body composition.
- Cherry supplementation did provide some protection against the OVX-induced decrease in trabecular bone in the lumbar vertebra, but was not able to prevent the decrease in whole body BMD and trabecular and cortical bone in the femur.
- Incorporating low dose tart cherry into the diet of an animal model of postmenopausal bone loss provides site specific protection for trabecular bone of the lumbar spine, but a higher dose or perhaps longer duration may be required to see an effect on the trabecular and cortical bone of the femur.
- Further studies are warranted to determine the dose-dependent and time course effects of cherry supplementation's effects on bone.

References

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