The relationship between activity and ions in patients with metal-metal bearing hip prosthesis

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Introduction
Metal-metal (MM) bearings are frequently implanted in young, active patients. Studies of Co and Cr ion levels have demonstrated patient to patient variability, which could, at least in part, be due to variability in patient activity. However, the relationship between activity and ion levels has not been scientifically investigated.

Material and Methods
Seven patients with well-functioning hip prostheses with a MM bearing and normal renal function, with a mean FU of 17 months, and one male control subject were included. Three patients had a conventional, cementless total hip replacement (THR) system, with a press-fit titanium acetabular cup (Pinnacle™, DePuy, Warsaw, IN), a CoCr metal liner (Ultimate™, DePuy, Warsaw, IN), and a proximally-fixed titanium emoral stem (Summit™, DePuy, Warsaw, IN) with a 36mm CoCr femoral head. One of these (Patient #1) had bilateral THR of the same design implanted at the same time. The remaining four patients had a non-modular, MM resurfacing arthroplasty (Conserve Plus™, Wright Medical Technology, Arlington, TN), with a cementless acetabular cup and a cemented femoral shell with a mean head size of 49mm (46 to 52mm). There were no other sources of metallic ions in these patients and no source of metallic ions in the control subject.

A two-week test protocol was used to evaluate changes in Co and Cr as a result of low-intensity activity (over one week), acute high-intensity activity (a treadmill test, TT), and high-intensity activity (over one week). Activity was quantitatively assessed using a computerized two-dimensional accelerometer (SAM, Stepwatch, Cyma, Seattle, WA). All patient activity data was extrapolated and reported as cycles per year (cpy). A total of 14 blood samples were obtained from each subject for the measurement of Co and Cr levels in serum: 1) two at baseline, 2) two during and after the low-intensity week (LIAW), 3) six during and after the high-intensity activity week (HIAW), 4) two the next day after the TT, and 5) two after the high-intensity activity week (HIW). The concentrations of Co and Cr in serum were measured with atomic absorption spectrophotometry.

Results
During the LIAW, patients recorded an extrapolated mean of 2.02 million cpy. During the HIAW, patients recorded an extrapolated mean of 2.51 million cpy (a mean increase of 28% activity, 95% CI, 13 to 43%; SE, 6%). During the hour-long TT, patients recorded an extrapolated mean of 31 million cpy (a mean increase of 1,621% [16 fold increase] in activity compared to the LIAW, 95% CI, 972 to 2,271%; SE, 265%). At the end of the LIAW, the mean serum Co level for all the patients was 1.41 ppb (range, 0.81 to 3.12 ppb; SD, 0.79 ppb) was measured for all patients during the TT, representing a mean increase of 3.0% per patient (95% CI, -5.7 to 11.7%; SE, 3.6%) when compared to the LIAW. At the end of the HIW, the mean serum level for all patients was 2.08 ppb (range, 1.34 to 3.8 ppb; SD, 0.90 ppb) (Figure 2).

Discussion
For patients in a physiological steady state, serum Co and Cr ion levels are not affected acutely by patient activity. Periodic measurements of serum ion levels can be used to monitor the tribologic performance of a MM bearing and the dissolution of this volume of wear particles is likely the major determinant of serum ion levels, with relatively little additional wear (and ions) generated in the steady-state. Additional research is needed into the kinetics of ion production, transport and excretion.