INTRODUCTION
Polyethylene wear remains a leading cause of osteolysis, aseptic prosthetic loosening, and subsequent failure in total hip arthroplasty (THA). Pre-clinical wear testing of acetabular liners has been a useful tool to predict clinical outcomes. Wear studies have investigated the impact of various materials, prosthetic designs, and sizes of the femoral head and acetabular cup couples. However, less testing has been performed on the effects of surgical malpositioning of the acetabular component, which is also thought to play an important role in the production of wear [1-5]. Inherent in these studies of component positioning are multiple variables that, in addition to abduction angle, can affect wear or wear measurements; i.e. cup migration, cup anteversion, and creep. These variables can be predictably controlled and studied in vitro settings. The objective of this study was to isolate and examine the effects of varying cup abduction angles on polyethylene wear.

METHODS AND MATERIALS
The acetabular components used for this study were the Trident™ design (Stryker Orthopaedics, Mahwah, New Jersey) with an inner diameter of 28 mm machined from GUR 1050 CM polyethylene to final dimensions. All of the inserts were vacuum and nitrogen gas flush packaged (N2/Vac); and sterilized by gamma-irradiation. The inserts were mounted in titanium acetabular shells. The shells were mounted in polyethylene fixtures using titanium bone screws. Matching diameter (28 mm) cobalt-chrome femoral heads were mated with the inserts.

Testing was conducted using a hip joint simulator (MTS, Eden Prairie, Minnesota). All cups were fixed, positioned superiorly to its matched femoral head at a neutral version angle, and divided into four groups of varying inclination angles from the horizontal plane: 0°, 40°, 50°, and 70°. The joint force in vivo is approximately 10° to 15° medial to the superior direction [6], therefore, due to the MTS simulator’s vertical load path, the cup inclination angles of 0°, 40°, 50°, and 70°; subsequently simulate the in-vivo conditions of approximately 10°-15°, 50°-55°, 60°-65°, and 80°-85° abduction angles, respectively.

The MTS simulator applies a biaxial rocking motion to the femoral head by a rotating block inclined at 23°. A physiological load similar to that described by Paul [7] was applied to each cup/head couple via a hydraulic actuator. The minimum and maximum loads applied were 50 N and 2450 N, respectively.

Testing was conducted at 1 Hz using a joint fluid analog of Alpha Calf Fraction serum (Hyclone Labs, Logan UT) diluted to 50% with a pH-balanced 20 mMole solution of deionized water and EDTA (protein level = 20 g/l). Serum was changed every 0.5 million cycles at which time, samples were cleaned and weighed. Weight was converted to volume and plotted as a function of cycle count. Using linear regression analysis, volumetric wear rates were attained. The testing was carried out for 3.0 million cycles. In addition, all UHMWPE inserts were macroscopically analyzed for any gross damage and areas of deformation. Any surface damage, such as cracking or pitting was recorded.

RESULTS
Macroscopic inspection of the polyethylene liners revealed wear scars and increased areas of polishing on inserts positioned at lower abduction angles.

DISCUSSION
These results indicate a reduction in wear with acetabular cup positioning at higher abduction angles in hip simulator testing. Visual inspection of the liners revealed a corresponding increase in overall area of polishing (wear) with a reduction in abduction angle. This may be due to increased head coverage as abduction angle decreases. Although load is concentrated over a smaller area resulting in increased contact stress for steeper cups, the effect of this increase in stress may be overshadowed by the increase in articulation area. The effect of increased contact stress on wear rates has been investigated previously with similar findings of decreased wear with decreased contact area [9]. While steep positioning may decrease UHMWPE wear, the positioning of the cup during a THA should be based on the preservation of anatomic position to optimize resultant joint movement, joint contact force, and abductor forces. Problems with steep cup positioning may include a greater potential for dislocation along with inadvertent rim fracture if the functional strength of the construct is suboptimal. This is especially true for re-melted crosslinked UHMWPE materials. Future studies should include finite element analysis which will reveal the changes in stress as a function of abduction angle, and assess the effect cup inclination on modern day hard bearings such as ceramic-on-ceramic and metal-on-metal.

REFERENCES

AFFILIATED INSTITUTIONS FOR CO-AUTHORS
†Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore, Baltimore, Maryland