INTRODUCTION:
Musculoskeletal complications induced by age-related diseases like osteoporosis, and in long-term disuse osteopenia such as a lack of microgravity during extended space missions and long-term bed rest, represent a key health problem. Such a skeletal disorder changes both the structural and strength properties of bone, and the latter plays a critical role in ultimately leading to fracture [1]. Early diagnosis of progressive bone loss or subtle changes of bone quality would allow prompt treatment, and thus would dramatically reduce the risk of bone fracture. Most osteoporotic fractures occur in cancellous bone. Hence, non-invasive assessment of trabecular strength is extremely important in evaluating bone quality. The principal diagnostic method for osteoporosis is currently dual-energy X-ray absorptiometry (DEXA), which provides an index of bone mineral density (BMD) and/or content, but not the bone's physical properties. Recently, advancements in ultrasonic techniques provide a method for characterizing the material properties of bone in a manner which is non-invasive, non-destructive, repeatable, safe and relatively accurate. Limitations with this approach, however, include the tissue boundary interaction, influence of soft tissue and cortical shell, and accuracy. These leave quantitative ultrasound (QUS) - in its current configuration - as a first order screening tool, rather than a highly accurate diagnostic for true fracture risk [2]. To overcome these hurdles and improve the specificity of non-invasive ultrasonic assessment, we have initiated a new modality of QUS by developing a scanning confocal acoustic diagnostic (SCAD) technology particularly for identifying the strength of trabecular bone [3]. The ultrasound resolution and sensitivity can be significantly improved by its configuration. The objective of this work was to longitudinally evaluate bone mass changes in a 90-day bed rest. The correlations between QUS parameters and DEXA determined BMD were performed.

METHOD:
The longitudinal evaluation of bone quality using SCAD and DEXA was performed in 90-day continuous bed rest in volunteers (2 males and 2 females). The subject were skeletal matured and in the healthy conditions. Both QUS and DEXA measurements were conducted in day 0 ( baseline), day 60 and day 90. The right foot of each subject was tested by the confocal scan QUS. The scanning region converged in the middle of the median plane of the calcanei, covering an approximate 40x40 mm2 with 0.5 mm resolution. All these waves were processed to calculate the ultrasound attenuation (ATT; dB), the logarithm of the ratio of the reference wave energy to testing wave energy, and the BUA (LONGITUDINAL)

**Table 1. Correlations between BUA-UV and BMD: **

<table>
<thead>
<tr>
<th></th>
<th>WB</th>
<th>PEL</th>
<th>L-NK</th>
<th>L-TRO</th>
<th>R-NK</th>
<th>R-TRO</th>
<th>SPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUA (POOLED)</td>
<td>0.84</td>
<td>0.57</td>
<td>0.46</td>
<td>0.5</td>
<td>0.45</td>
<td>0.35</td>
<td>0.55</td>
</tr>
<tr>
<td>UV (LONGITUDINAL)</td>
<td>0.85</td>
<td>0.98</td>
<td>0.99</td>
<td>0.73</td>
<td>0.93</td>
<td>0.81</td>
<td>0.09</td>
</tr>
<tr>
<td>BUA (LONGITUDINAL)</td>
<td>0.99</td>
<td>0.32</td>
<td>0.87</td>
<td>0.52</td>
<td>0.79</td>
<td>0.38</td>
<td>0.99</td>
</tr>
</tbody>
</table>

**DISCUSSION:**
It has been demonstrated that the in vivo assessment of bone quality using BUA predicts overall BMD distributions in all pooled subjects and longitudinal testing. UV measurements has shown its capability to sense subtle changes in bone in the longitudinal BMD alteration, i.e., prediction of 1.5% UV reduction for 60 day bed rest. Using a confocal scan model, QUS has demonstrated sensitivity to bone mass changes, particularly in the trabecular bone region. Based on detected trabecular bone images, the best representative ROI can be identified to characterize the bone properties. One obvious advantage of choosing ROI is that this procedure can decrease the inaccuracy of experiment result by getting rid of the points at the edge of bone and the soft tissue, whose values are unstable because of the edge effect of ultrasound wave. The high correlation between BUA and BMD demonstrates that BUA is a good indicator of bone density and it can also serve as a good indicator of disuse osteopenia. The high correlation exists between BUA and femoral neck BMD implied that calcaneus BUA can also be a good predictor of hip and pelvis bone density, which is a better skeletal site for assessing osteoporosis and prediction of bone fracture. These preliminary data suggest that prolonged exposure to simulated disuse may lead to a lower UV [4] and altered BUA, which then could be used for the longitudinal and instant follow-up of bone demineralization occurring during long-term space flights.

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REFERENCE: