Purpose: To investigate a novel methodology of converting x-ray sinograms into proton sinogram, which can be used to replace the missing part of an actual proton sinogram due to the limited-range problem.

Methods: Modeling has shown that there exist correlations between proton projection and multispectral x-ray projection for materials in the human body. Based on these correlations, materials can be categorized into: A) adipose tissue, B) non-adipose soft tissue, C) bone. These three categories can be identified on a regular x-ray computed tomography (xCT) image without much effort. With an xCT image and its sinogram available, the x-ray sinogram can be converted to the corresponding proton sinogram by: 1) converting the x-ray raysum through adipose and non-adipose soft tissues using the pre-determined relationships and the relative portions of two types of material along the ray; and 2) by correcting for bone if the ray passes through it. In a proof-of-principle study, numerical simulations were done. The converted proton sinogram was compared to the simulated one. The converted proton sinogram is used to make up the 200 MeV proton projections through water-equivalent depth (WED) larger than 20 cm, which are then combined with simulated proton projections through WED < 20 cm for pCT stopping power reconstruction.

Results: A sinogram profile for view angle = 0 showed the converted projections had a mean error of -0.13% (standard deviation 1.7%), RMS error of 0.20%, compared to the simulated one. The pCT stopping power image reconstructed using the sinogram with converted part (13.5% of total projections) showed a mean error of only +0.3% (standard deviation 4.6%).

Conclusions: The proposed methodology allows one to convert x-ray sinograms into proton sinograms with a reasonable accuracy, and is particularly useful to address the limited-range problem of pCT scanning.