Barchan morphology has been the subject of considerable research, mainly because they frequently occur as stand alone features with iconic, aerodynamic forms. Barchans retain their distinctive shape independent of size, indicating proportionate change of key shape metrics. The early work of Pompeckj (1906), Finkel (1959), and others, noted that barchan widths and heights displayed this property. Hesp and Hastings (1998) recognized this as an allometric relationship. Allometric relationships are identified by power law ratios between shape elements.

We present the results of a study where we measured barchans of different sizes and from different environments to develop new shape metrics and to evaluate potential allometric relationships between those metrics. We used remote sensing imagery obtained from Google Earth Pro (Google Earth and Google Mars) to sample barchan morphology from 40 dunes fields: 30 on Earth and 10 on Mars, comprising 3,406 barchans: 2,687 from Earth and 720 from Mars. We measured six morphometric variables and derived three dimensionless ratios for each dune. Body length \( L_1 \) is the shortest distance from the upwind point of the barchan to the bottom of the slipface. Total length \( L_2 \) is the body length plus the average length of the two horns. Body width \( W_1 \) is the length measured from the outside edges of the barchan along a line at the base of the slipface and perpendicular to the body length line. Horn-to-horn width \( W_2 \), is calculated using the Pythagorean Theorem as \( \sqrt{H_1^2 + H_2^2} \), where \( T \) is the distance between the tips of the two horns, \( H_1 \) is the length of the left horn (looking into the slipface) and \( H_2 \) is the length of right horn. The dimensionless shape metrics are the width ratio, \( WR \); the length ratio, \( LR \); and the symmetry ratio, \( SR \), (longer horn length/shorter horn length).

Regression analysis to test for allometric relationships requires the designation of independent and dependent variables. For the former, we chose body width \( W_1 \) as a potential control on variability in \( L_1 \), and \( L_2 \), for assessment of dimensional relationships. For assessment of dimensionless relationships, we used \( WR \) as the independent variable with the dependent variables of \( LR \), and \( SR \). For Earth and Mars data combined, the dimensional ratios had \( R^2 \) of 0.90 for \( W_1 \) and \( L_1 \), and 0.80 for \( W_1 \) and \( L_2 \). The power law relationships both had exponents near 1.00; 0.995 and 0.999, respectively. Coefficients of determination and exponents differed, however, between the two planets. Data for the two ratios indicated that for Earth, \( R^2 \) was 0.91 and 0.80, with exponents of 0.904 and 1.065, respectively. The equivalent values for Martian dunes are 0.64 and 0.60, with exponents of 0.761 and 0.983. Similar differences are found for the two planets using the dimensionless variables, although the relationships between \( WR \) and \( SR \) are weak \( R^2 < 0.19 \).

From this, and other analysis, we can conclude that the allometric relationships between barchan metrics are different for terrestrial and Martian barchans. This means, further, that typical barchan morphology must also differ between the two planets.