The poor convective heat transfer coefficient between the absorbing plate and air could result in a decrease in the thermal efficiency of the solar air heater. A semi-analytical model was developed in MATLAB environment was used to predict the thermal–hydraulic efficiency *(ηeff*) of a V-groove solar air collector (VSAC) integrated with transverse wedge-shaped ribs (TWSR) beneath the absorbing plate. The influence of design parameters, namely pitch ratio (*p/e*) of 5.67–15, and relative height ratio (*e/Dh*) of 0.02–0.07, on the thermal–hydraulic efficiency is investigated, with mass flowrates of 0.021–0.126 kg/s. The optimal values of *p/e* and *e/Dh* are examined using data for actual climatic conditions. The results indicate that the *ηeff* of the VSAC-TWSR is greater than that of the smooth VSAC. Moreover, the *ηeff* increases with increasing flowrates to a specific value and then decreases while thermal efficiency is directly proportional to the mass flowrates. In addition, the optimal thermal enhancement is achieved at *p/e* = 8 and *e/Dh* = 0.07. The thermal efficiency increases by about 8% when ribbed as opposed to smooth surface are used. The heat gain of a proposed design enhanced by about 9% and the maximum increase in the thermal–hydraulic efficiency is 9.6% compared to the smooth design when the mass flowrate is 0.084 kg/s.