The scaling of human basal metabolic rate in adult males

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Body size is the primary determinant of basal metabolic rate, with that relationship being an alinear function across mammalian species ($mass^{0.67}$: White and Seymour, 2003) and revealing disproportionate increases in metabolic rate with increments in body size. Therefore, inter-species (mass-specific) comparisons made using arithmetic normalisation are erroneous. To date, however, it remains to be established whether human-specific, basal metabolic rate also follows this same alinear trend. Accordingly, this investigation was designed to test the hypothesis that basal metabolism in adult males will scale as a power function of body mass, and with an exponent similar to that observed for other mammalian species.

Oxygen consumption was measured in 30 males (22 y [±2.5], 78.14 kg [±11.98, range 59.19-108.5]) using open-circuit, indirect respirometry. Basal metabolic rate was then estimated using Weir's non-protein respiratory quotient formula. Absolute metabolic rate ($kJ.day^{-1}$) and oxygen consumption ($mL.min^{-1}$) were used to assess the scaling relationship between basal metabolism and body size. Deep-body temperature was measured using an auditory-canal thermistor and used to standardise metabolic rate to a common temperature (36.2°C). Data were collected at 07: 00 h after a 12-h fast, and over a 60-min duration in a low-stimulus and normothermic environment (~23°C; ~50% relative humidity). To reduce inter-individual variability, participants were recruited who had a height-adjusted (170.18 cm) sum of skinfolds (seven sites) <80 mm, and metabolic data were standardised to a common deep-body temperature.

A group comparison, taking the ten largest (89.9 kg [±11.3]) and ten smallest (64.5 kg [±4.1]) individuals, revealed a significant difference between mass-specific (linearly normalized) basal metabolic rates ($kJ.kg^{-1}$: $P<0.05$). This verified that, even across this relatively small adult mass range, mass-specific basal metabolism rate is size dependent and alinear. It was therefore not surprising to find that the basal metabolic rate could be scaled as a power-function of body mass ($mass^{0.64}$: $r^2 = 0.73$, $P<0.05$). Moreover, that power function was not dissimilar to that reported for a wide range of mammals, with the 95% confidence interval for the exponent ranging between $mass^{0.53}$ and $mass^{0.82}$. Normalising these basal data to a common deep-body temperature, however, did not significantly alter the strength of the association between body mass and basal metabolic rate ($r^2 = 0.73$, $P<0.05$).

To the best of our knowledge, these observations represent the first verification that human basal metabolic rate also scales as a power function of body mass in healthy, adult males. This may be partially explained on the basis of inter-individual variations in the sizes of the most metabolically active tissues. Regardless of the causal mechanism, this non-linear relationship has confirmed that the frequently applied arithmetic mass normalisation of human basal metabolism ($kJ.kg^{-1}$) lacks validity and can introduce spurious interpretations. As a continuation of this theme, we are extending this work to include steady-state, non-basal conditions involving postural changes, ambulation and load carriage.

White CR & Seymour RS. (2003). *Proc Natl Acad Sci USA*, **100**: 4046-9.