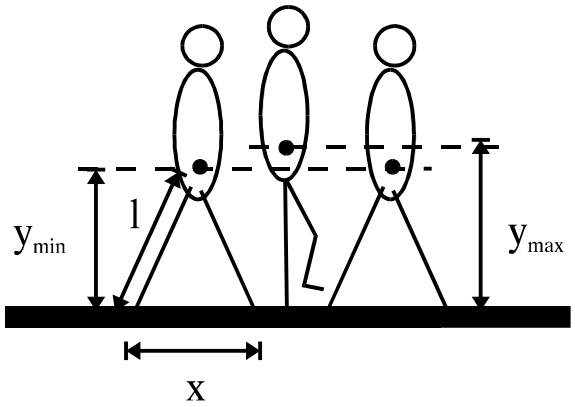
During the walk, the center of mass of the body periodically moves up and down (see the figure below) by a value of $h = y_{max} - y_{min}$. The muscles perform a work of $A = mgh$ against the gravity during rising the center up, and therefore the body consumes additional energy from oxidation of its internal, chemical sources. When the center of mass moves down, it is the gravity which perform a positive work, which is however not restored back in a form of chemical energy due to the irreversible character of the process of oxidation, but is rather dissipated into heat. Therefore, the average power consumed from oxidation, during one step is:

$P = M + mgh/t$

where $t$ is the time for making one step and $M$ is the rest-power. From geometrical consideration we have $h = l - \mathrm{sqrt}[l^2 - (x/2)^2] \sim x^2 / (8*l)$, taking into account that the half of the step $x/2$ is usually considerably smaller then the length of the leg $l$. Since the time for one step is $t = x/v$, we finally obtain the desired dependence:

$P = M + K*v$

with $K = mgx/(8*l)$. For a man of $m$ = 80 kg, $l$ = 0.9 m, $x$ = 0.4 m we have $K$ = 44 N. Therefore, the energy consumption during a fast walk ($v$ = 2 m/s) approximately doubles with respect to its rest value.