Carrying for free? Testing human capability of load transport without added costs

Prado-Nóvoa, O.[a], Rodríguez, J.[b], Zorrilla-Revilla, G. [b], Vidal-Cordasco, M. [a], Mateos, A. [b]

[a] Postgraduate School of Human Evolution, University of Burgos. C/Don Juan de Austria 1, Burgos, 09001, Spain.
[b] National Research Center on Human Evolution (CENIEH). Paseo Sierra de Atapuerca 3, Burgos, 09002, Spain.

prado.novoa.olalla@gmail.com

Introduction & Methodology

Several researches propose that humans have extremely efficient carrying methods, without incurring any extra locomotion costs, named "Free Ride Hypothesis" [1-3]. Nonetheless, recent investigations do not agree with this assumption [4]. Due to the relevance of carrying behaviors for human ecology [5, 6], to evaluate this "Free Ride" capacity is still of interest. Thus, 48 individuals of both sexes were recruited, and the next variables were measured and assessed:

Measurements

N=48
21♀ - 27♂

Dataset: [I]Energetic expenditure during walking and load-carriage in humans. Dataset from EVOBREATH 2015[I] [7].

- Body Mass (kg)
  - Digital standard scale
- Energy Expenditure (mlO_2)
  - Indirect Calorimetry (Master Screen CPX, Jaeger ™ device and LabManager IntelliSupport 5.2 app)
    - Resting 30 min (RMR)
    - Walking 10 min
      - Unloaded (W_U)
      - Carrying 5 kg (W_5)
      - Carrying 10 kg (W_{10})
      - Carrying 15 kg (W_{15})

Assessments

Net Cost= Gross walking costs - RMR

Relative Carried Load (RCL) = $\left(\frac{Carried\ Load\ (kg)}{Body\ mass\ (kg)}\right) * 100$

Increment Net Cost (%)= $\left(\frac{Net_L mlO_2 - Net_U mlO_2)}{Net_L mlO_2}\right) * 100$

Where $Net_L\ mlO_2$ is the net cost of load trials, and $Net_U\ mlO_2$ is the net cost of the unload trial

Statistical analysis

T-student tests between:
-Loaded and unloaded walking tests (Gross and Net Cost)
-RCL and the Increment Net Cost (%)

Simple correlation considering alternative models with RCL (x axis) and the Increment Net Cost (%) (y axis)

Results & Discussion

The gross cost of W_{10} and W_{15}, and the net cost of W_{10} are significantly greater than the cost of W_U. The lack of significant differences between net W_{15} and net W_U costs could be explained by the high data scattering, detected on previous studies [8] (Table 1). Thus it is interesting to relativize the data to reduce individual variability. There are not differences between RCL and the Increment Net Cost (%) (Table 2).

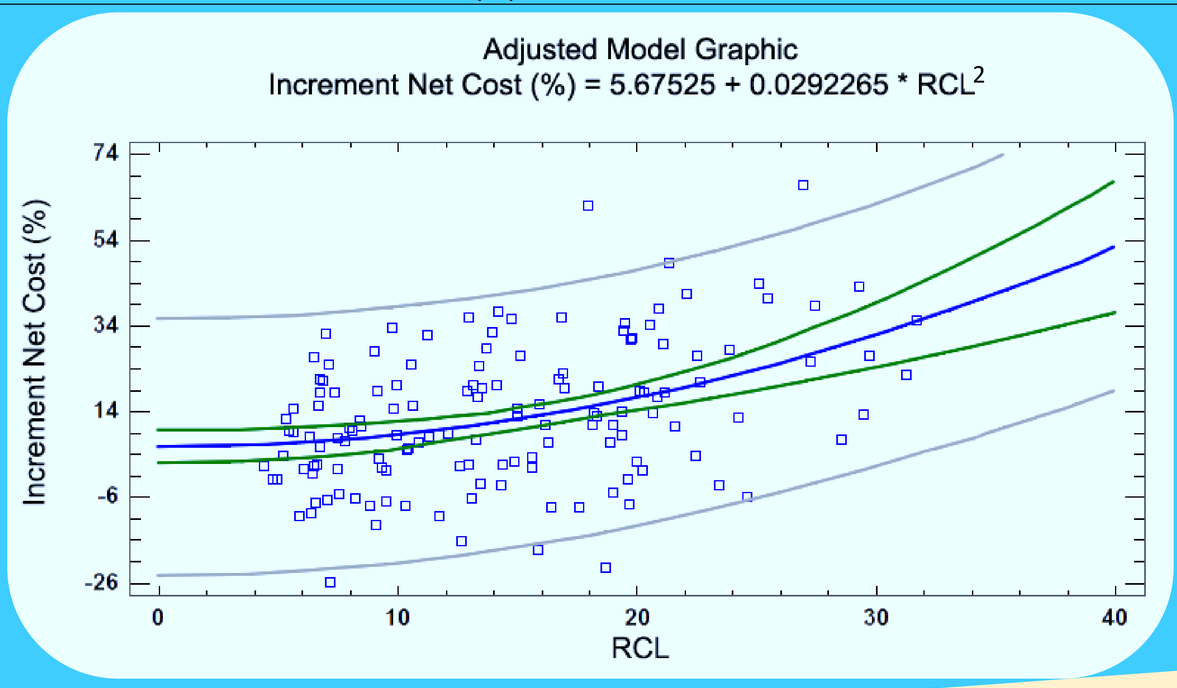
The regression model that better fits (highest r^2 value) the relationship between RCL and Increment Net Cost (%) is a quadratic model (Table 3). So, the costs of locomotion do not increase in all the individuals proportionally to the burden carried, contrary to what mean values on Table 2 seem to show. Hence, for RCL above 20% the locomotion costs increase exponentially, while with lesser values of RCL the carrying costs remain stable. Nonetheless, although not significantly, all the loads carried increase de costs of W_U.

TABLE 1	Mean (SD)
Body Mass	70.93 (15.94)
RMR	240.48 (50.09)
Gross cost W_U	725.29 (182.06)
Gross cost W_5	762.81 (173.24)
Gross cost W_{10}	798.38* (162.59)
Gross cost W_{15}	845.33** (157.89)
Net cost W_U	484.81 (148.75)
Net cost W_5	522.33 (140.32)
Net cost W_{10}	557.90* (132.81)
Net cost W_{15}	552.02 (232.78)

TABLE 2	RCL	Increment Net Cost (%)
	Mean (SD)	Mean (SD)
5 kg	7.40 (1.62)	7.52 (12.66)
10 kg	14.79 (3.24)	13.42 (16.53)
15 kg	22.19 (4.86)	18.80 (17.82)

T-tests between unloaded and loaded trials:
* $p < 0.05$
** $p < 0.01$

TABLE 3			
Model type	Equation. Increment Net Cost (%)=	*p*-value	r^2
Quadratic	Increment Net Cost (%) = 5.67525 + 0.0292265 * RCL^2	<0.001	15.96%
Linear	Increment Net Cost (%) = -0.828271 + 0.963361 * RCL	<0.001	15.83%
Squared root of x	Increment Net Cost (%) = -13.2647 + 7.13117 * √RCL	<0.001	15.17%
Logarithmic	Increment Net Cost (%) = -18.4548 + 12.3502 * ln (RCL)	<0.001	14.16%
Inverse of x	Increment Net Cost (%) = 23.8608 - 122.2 / RCL	<0.001	11.58%



Therefore, a "Free Ride" capacity in our sample is discarded, although it can be highlighted that the costs of locomotion are only significantly incremented when the heaviest loads are carried. To carry 5, 10 and 15 kg of food resources cover in excess the cost of their transport (2 hours over a flat terrain at a constant speed of 4 km/h) [6]. However, to present certain load transport energetic efficiency makes sense when the burden transported does not represent a direct energetic benefit, as burdens like dependent children or raw materials. These load transport activities are daily life behaviors among current hunter-gatherers and are considered essential to understand human evolution.

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