Editorial for Experimental Physiology?

Travelling back to normal

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One of the possibly unforeseen consequences of the Covid-related lockdowns and changes in working practices was a reduction in carbon dioxide (CO_2) production. With a 6.4 % (13 % in the USA) or 2.4 billion tonnes reduction in CO_2 production in 2020, the virus achieved more in two years than humanity has in a quarter of a century (1). The sector most affected by the lockdowns was air travel, where CO_2 emissions fell by 48 % from their 2019 total (2). However, the rebound was fast and furious: carbon emissions from burning fossil fuels rose by 4.9% to 36.4 billion tonnes/year in 2021 compared with 2020 (3). As life returns to 'normal' and people start travelling to work, meetings and conferences, the expectation is that the carbon cost of transport will continue to increase.

In The Physiological Society booklet "Physiology and climate change" (4) we suggest some actions people can take to reduce their carbon footprint. In an extension of this, we present in Table 1 the carbon costs of different forms of transport to help enable informed decisions about how, and if, to get from A to B. Unusually, we have included the carbon production (in grams) associated with human self-propelled activities for information and as a comparator. These data are seldom reported in this form ($g.km^{-1}$).

Just to put these data into some kind of context, 1 kg of CO_2 is about 545 Litres (L) (depending on temperature and humidity). One fifth of that (nearly 110 litres) will still be cooking our planet in 33,000 years' time, and 7% (38 litres) 100,000 years from now. From Table 1, we see that a long-haul flight produces 599.25 g of CO_2 per passenger km. That equates to 326.95 L of CO_2 per passenger per km. So, the 5,570 km flight from London to New York with 450 passengers produces 819,500,175 L of CO_2. About 20 % of that (163,9009,035 L) will still be contributing to global warming in 33,000 years. And that's one flight from London to New York. There are 15 companies offering up to17 daily flights on just this route. Incidentally, assuming all the passengers are resting, and a flight time of 8 hours, adds another 82 kg (47,734 L, 0.38 $g.min^{-1}$) of human CO_2 production. However, we ignore this as a contribution because it would be produced in all situations if alive.

Table 1. Carbon cost of transport in 2018 (grams of carbon dioxide equivalent per individual kilometre travelled[1] (From: [5]). Figures in **red** are calculated for different forms of human-powered transport (Assumptions: 70 kg body weight, RER =1. Data corrected for resting VCO_2).

Transport type	**Greenhouse gas emissions per passenger kilometre (gCO_2e)**
Long-haul flight (first class)	599.25
Long-haul flight (business class)	434.46
Large car (petrol)	282.95
Domestic flight	254.93
Long-haul flight (economy+)	239.70
Short-haul flight (business class)	233.60
Black cab (taxi)	211.76
Large car (diesel)	209.47
Medium car (petrol)	192.28
Medium car (diesel)	170.61
Short-haul flight (economy)	155.73
Small car (petrol)	153.71
Taxi	150.18
Long-haul flight (economy)	149.81
Small car (diesel)	142.08
Motorcycle (large)	135.01
Large car (hybrid)	131.77
Ferry (car passenger)	129.52
Medium car (hybrid)	108.95
Small car (hybrid)	105.20
Bus	104.71
Motorcycle (medium)	102.89
Petrol car, 2 passengers	96.14
Diesel car, 2 passengers	85.31
Motorcycle (small)	84.45
Large car (plug-in hybrid electric)	77.31
Medium car (plug-in hybrid electric)	70.83
Large electric vehicle (UK electricity)	66.88
Swimming at 3 $km.h^{-1}$	**54.13**
Medium electric vehicle (UK electricity)	53.17
Petrol car, 4 passengers	48.07
Small electric vehicle (UK electricity)	45.67
Diesel car, 4 passengers	42.65
National rail	41.15
Light rail and tram	35.08
London Underground	30.84
Small car (plug-in hybrid electric)	29.35
Coach	27.79
Running at 10 $km.h^{-1}$	**24.72**
Walking at 5 $km.h^{-1}$	**20.14**
Ferry (foot passenger)	18.74
Cycling at 20 $km.h^{-1}$	**9.66**
Eurostar (international rail)[2]	5.97

[1]The carbon footprint of travel is measured in grams of carbon dioxide equivalents per passenger kilometre. This includes carbon dioxide, but also other greenhouse gases, and increased warming from aviation emissions at altitude. A carbon dioxide equivalent or CO_2 equivalent is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential, by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential. [2]Eurostar runs mainly on electricity from French nuclear plants.

As decisions are made about the future of meetings and conferences, it would be counter-intuitive, not to say hypocritical, for those concerned about the immediate and grave threat posed by climate change not to consider how they organise meetings (of all sizes) and how they attend them. As part of this consideration, it is worth noting that whilst being regarded as a green alternative to in-person meetings, virtual meetings are not without costs in terms of the climate. It has been calculated (6) that the costs of such meetings (network operation, videoconferencing equipment use, maintenance and replacement, video quality and number of people at the meeting) are at most 7 % of the energy/carbon footprint of in-person meetings. For example, the technology used by two people on a HD Zoom call for one hour will generate about 0.0037 kg of CO_2. A weekly meeting with six participants, watching in HD 1080p for one hour, releases 0.05 kg of CO_2 or up to 2.6 kg over a year (6, 7). Replacing a video call with an email saves energy, and the extent of this can be calculated (8). Of course, switching to a 100% renewable electricity supplier helps, and 'green internet service providers' are also available. For information, a tree can draw down 10-40 kg of CO_2 a year when mature, but perhaps only 5.9kg while growing (9).

Finally, when organising an in-person meeting, there are lots of things that can be done to minimise the damage to the climate associated with that meeting, from venue choice, to food and drink provided. This topic warrants separate consideration.

There is no doubt that in-person meetings and conferences offer benefits not available by other means. Let's not also forget the negative impacts on mental and physical health of social isolation and sedentary lives and the carbon costs of healthcare when one is ill, while remembering the positive impacts which physical activity brings. So, walking or cycling to a meeting has advantages too.

Our aim in producing this short paper is to help people calculate the cost/benefit of: the type of meeting they run; how people travel to or attend such meetings; and the number of people who go.

Just to be clear, the "cost" here is defined in terms of the survival of our species, so worth a moment's thought.

Acknowledgements

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