

How compositional data analysis can help us optimise our daily routine to be healthy

December 16 2015, by Travis Saunders

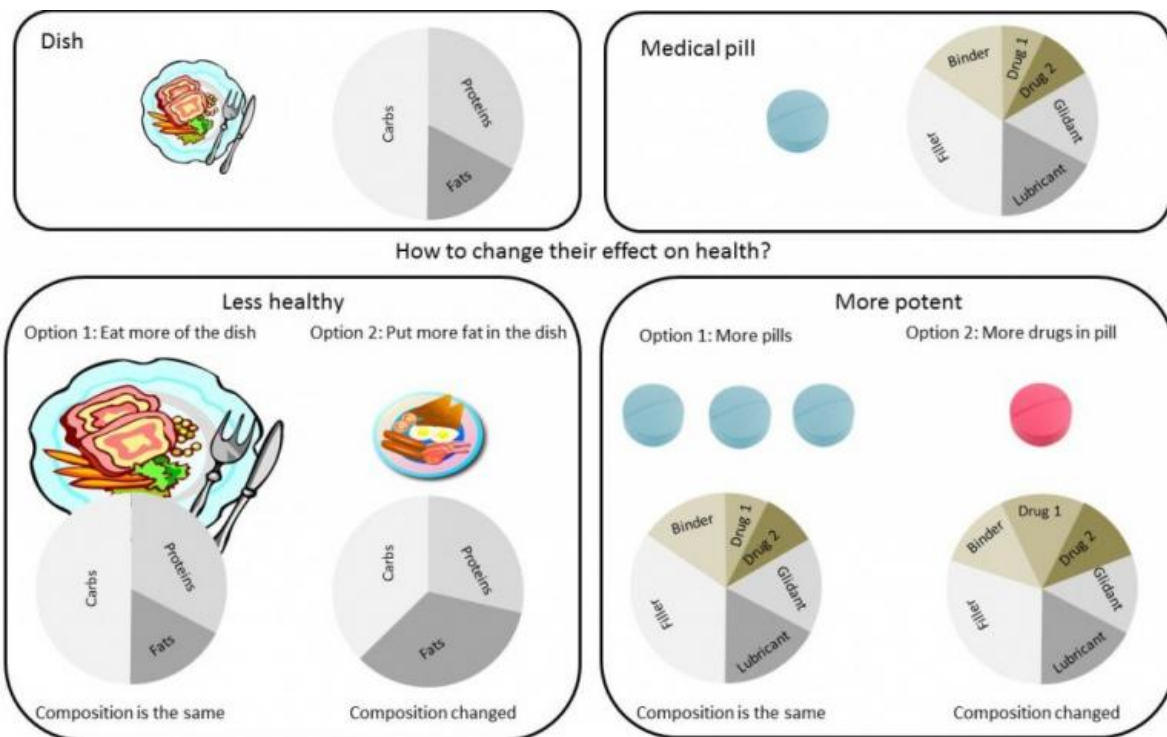


Figure 1: Schematic illustration of common composition and how the composition determines their effect.

What is the recipe for a healthy day?

This is the question we explore in our [research article](#) "Combined Effects of Time Spent in Physical Activity, Sedentary Behaviors and

Sleep on Obesity and Cardio-Metabolic Health Markers: A Novel Compositional Data Analysis Approach" published by PLOS One. In this article, we argue that if we really want to know how much time we should spend; sleeping, sitting, standing, walking and exercising every day to be in good health, we have to adopt a compositional data paradigm. This is because, it is the only adequate mathematical representation of the pattern of time spent in different activities or behaviours throughout the day. In other words, one that takes into account the fact that time spent in one type of activity cannot be spent in another type of activity.

While developing this novel approach, initially just to overcome some technical issues with collinearity, we realised that it was more than just a new statistical technique. It actually provided an interesting unifying conceptual framework to study the impact and determinants of daily pattern of time use in an integrated and multidisciplinary way. In this blog piece, I would like to touch on some of these aspects.

It is helpful first to think about some analogous problems.

If I want to cook a tasty and healthy dish, nutritionists tell me that I have to combine in my recipe the right proportion of fat, carbohydrates, protein, vitamins, etc... and a good chef will tell me what ingredients to use and in what proportion. In the same way, to formulate an effective pill, pharmacologists combine active and inert compounds in the right proportions, ensuring that all ingredients are compatible and that their interactions do not alter or blunt the desired effect. Both my dish and the medical pills are fundamentally compositions. A composition is an entity of multiple non-overlapping parts which sum to a whole. Figure 1, shows different compositional representation of my dish and a medical pill, in graphical and mathematical terms. I apologise to nutritionists and pharmacologists if I did not get the number quite right to make these compositions actually healthy.

Similarly, our pattern of time use during the day is fundamentally a composition. For example we might describe the pattern of daily time use as

24 hour day = 8 hours (33.3%) sleep + 8 hours (33.3%) of work + 8 hours of leisure (33.3%)

OR

Waking day = 2% Moderate to [vigorous activity](#) + 38% Light activity + 60% Sedentary behaviour



How to change their effect on health?

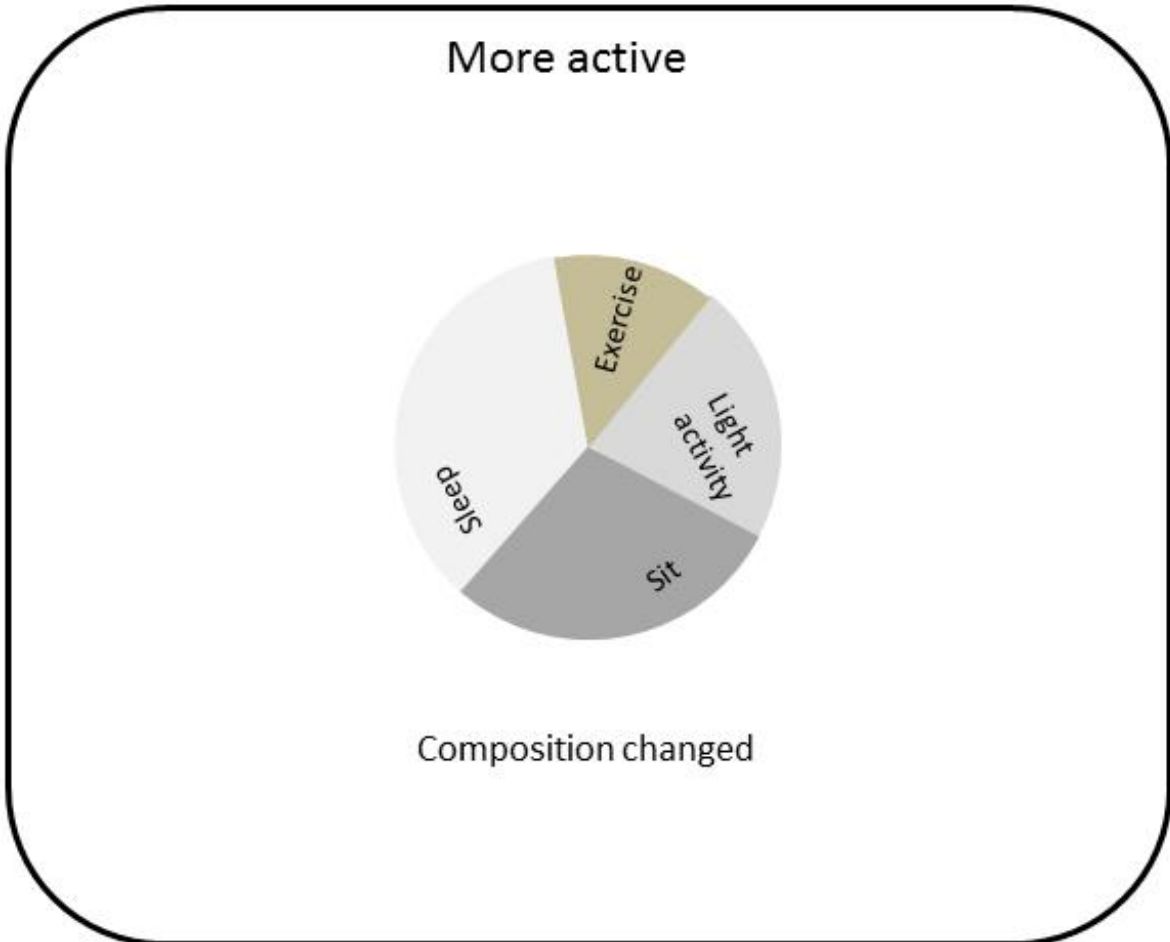


Figure 2: Daily activity as a composition.

I am sure that you have, at least once, represented the pattern of daily time use with a pie chart as in figure 2. You might not have realised it but this is already compositional data analysis, but let's see how we can take it further.

An interesting property of compositions is that their effect is determined by the proportion of the various basic ingredients that constitute them and not solely by the amount of one of these.

Surely, not! Let's see how we can change the effect of my dish or pill. To make my drug more potent I need to absorb more of the active ingredient. To do this I can either take more pills of the same composition, or I can include more active ingredients in my pill, changing its composition. Similarly, I can eat less fat if I include less fat in my dish, but then its composition changed or I can eat less of the dish but I am still swallowing the same composition. In either case, the dose response depends on both the composition and the size.

This property becomes more important in the context of time use because to be healthy we can only change the composition of the day – we can't make it any longer or shorter! In our paper we have actually shown that the composition of the day in terms of time spent in sleep, sedentary behaviour, light and moderate to vigorous activity is associated with adiposity and cardiometabolic markers. To be more active, I have to change the composition of my day. if I want to go to the gym and exercise I have to take time away from something else.

Conceptually, this is quite a departure from how we have usually considered time spent in physical activity, sleep or sedentary behaviour research. To date, we have conceptualised these as independent quantities of time and our reasoning and all the statistics we use to probe for evidence are based on this assumption. For example, we considered that health depends on the amount of time we spend exercising daily but

did not address the fact that this time depends on the composition of the day. Our models and evidence rest on the underlying assumption that this time can be increased to infinity. Our current recipe for a healthy day is a minimum of daily 30 minutes of moderate to vigorous activity. This is roughly 2% of the time we have in a day. This recipe assumes that the remaining 98% of the day either has no impact on health or just the mirror opposite effect. This Manichaeian concept would work if exercise was indeed the only ingredient of the day that impacts health.

However, we have more recently started to consider, that too much sitting might be bad for health, that sleep time is important for health, and that time spent in light activities might influence adiposity and glycaemic control. Since then, we have struggled to integrate and explain these within our current conceptual model of the day. This has led to some interesting controversies. A good example is contained in the article by Maher et al. 2014 published in PloS One and the comments it attracted. Some scientists claim that sitting has effects on health regardless of the amount of moderate to vigorous activity, while others respond that sitting time is just inactive time and that the associations reported are only due to sitting displacing [physical activity](#). This will be familiar to you, and I have certainly heard the same arguments in numerous conferences. I found neither of these hypothesis satisfying. On one hand is it really reasonable to consider that the effect of sitting is independent when we know that time spent sitting and active are necessarily co-dependent and sitting necessarily displaces some active time? On the other, the dualist view activity/inactivity does not explain some of the lab results we have on sitting and can't account for the differences in effect we observed between sitting and light activity. Our field of research seems to be polarised in a dead lock as evidence seems to remain equivocal and flaunt by statistical difficulties such as collinearity.

This is why compositional data analysis is so attractive, it certainly

enables us to overcome collinearity issues and to account in statistical models for time spent in all behaviours or categories of activity. But more importantly it offers a unifying way forward.

From a compositional stand point, the hypotheses above are not antithetic but complementary. Spending time sitting can have both specific health effects and displace active time thus contributing to the effects of inactivity. Our results clearly show this. The compositional approach does not invalidate or contradict any of our evidence to date; actually our results are consistent with it all. Instead it provides a sound theoretical framework and the practical statistical tools to integrate them so that we can move forward.

Let's face it most of us struggle to fit in 2% of our time in exercise, so finding out how to optimise the rest of the day is of interest to a lot of people. Besides that, we cannot exercise all day, so why not act on the whole distribution of time to improve health. Compositional analysis can help us get to the recipe for healthy day.

We are currently developing resources, training material and workshops about compositional data analysis and we would like to hear from people who might be interested in these or better in helping and collaborating toward developing a larger open science project using compositional data analysis to formulate the recipe for a healthy day.

More information: Sebastien F. M. Chastin et al. Combined Effects of Time Spent in Physical Activity, Sedentary Behaviors and Sleep on Obesity and Cardio-Metabolic Health Markers: A Novel Compositional Data Analysis Approach, *PLOS ONE* (2015). [DOI: 10.1371/journal.pone.0139984](https://doi.org/10.1371/journal.pone.0139984)

Sebastien F.M. Chastin et al. Meta-analysis of the relationship between breaks in sedentary behavior and cardiometabolic health, *Obesity* (2015).

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Measurement issues and poor adjustments for physical activity and sleep undermine sedentary behaviour research. *Kinesiology*. 2014;46: 135–146.

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