Why Vigorous Physical Activity Is More Effective: A Possible Explanation

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Formulation of the problem. Regular physical activity is important for maintaining ones health. Current activity recommendation suggest a certain overall amount of weekly physical activity. It may be vigorous, in which case this recommendation can be fulfilled in a shorter time period. It can be moderate, in which case the recommendation takes longer to fulfil. This recommendation implicitly assumes that the most important factor is the overall amount of physical activity, and that it does not matter much whether it is performed vigorously or not. Contrary to this impression, a recent study showed that in terms of health benefits, rigorous activity is more effective. How can we explain this?

Analysis of the problem. For a given overall level of, e.g., daily physical activity D, we need to select a schedule that would allow the best health benefits. Each schedule can be described by a function $D(t)$ that describes how much physical activity we perform by time t. For large t – close to the length of the day – we should have $D(t) = D$.

Optimality: a brief reminder. Optimization means that on the set A of all possible alternatives, there is a transitive relation $a \succeq b$ meaning that a is better than b – or of the same quality – with respect to the given criterion. If for this relation there are several different best alternatives, this means that our criterion is not final: we can use this non-uniqueness to optimize something else and thus, to modify the original criterion. So, for the final criterion, there should be exactly one optimal alternative.

Invariance and optimality. In many practical situations, there is some transformation g that does not change the corresponding physics. For example, when we change from minutes to seconds, numerical values change as $g(t) = \lambda \cdot t$ for $\lambda = 60$, but the relation between time intervals remain the same. In such cases, it makes sense to consider optimality criteria $\succeq$ that are g-invariant: $a \succeq b \Leftrightarrow g(a) \succeq g(b)$. It is known that for final g-invariant criteria, the optimal alternative $a_{\rm opt}$ is also invariant, i.e., $g(a_{\rm opt}) = a_{\rm opt}$.

Let us apply these ideas to our problem. It seems reasonable to assume that the relative quality of different activity schedule should not depends on what unit we choose to measure time. Then, we will be able to conclude that the optimal schedule should be invariant with respect to such scalings, i.e., that for each $\lambda > 0$, we should have $D(\lambda \cdot t) = D(t)$.

We know that $D(t) = D$ for all sufficiently large t – i.e., for $t \geq t_0$ for some t_0. For any $t > 0$, we can always select $\lambda > 0$ for which $\lambda \cdot t \geq t_0$ and thus, $D(t) = D(\lambda \cdot t) = D$. This means that in the optimal schedule, all the physical activity should be performed right away, at the starting time $t = 0$. In practice, this means that we should fulfil this requirement as fast as possible – i.e., this activity must be as vigorous as possible. This is exactly the empirical recommendation – and we have justified it.