European Heart Journal (2022) **43**, 4815–4816
https://doi.org/10.1093/eurheartj/ehac626

EDITORIAL

The hare and the tortoise: physical activity intensity and scientific translation

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Online publish-ahead-of-print 27 October 2022

This editorial refers to 'Vigorous physical activity, incident heart disease, and cancer: how little is enough?', by M. N. Ahmadi *et al.*, https://doi.org/10.1093/eurheartj/ehac572 and to 'Physical activity volume, intensity, and incident cardiovascular disease', by P. C. Dempsey *et al.*, https://doi.org/10.1093/eurheartj/ehac613.

Aesop's fable, the Hare and the Tortoise, tells the story of a race between a sprinting high intensity hare and a slower and presumably lower intensity tortoise. Of course, the tortoise unexpectedly won the race, and one interpretation of the fable is 'the race is not always to the swift'.[1] Two studiess in this issue of the *European Heart Journal* sought to advance our understanding of the health benefits of the hare's higher intensity strategy. Dempsey and colleagues[2] report a lower risk of cardiovascular disease (CVD) with higher levels of physical activity energy expenditure (PAEE) and that expending more energy in moderate to vigorous intensity activities provides additional protection. Ahmadi and colleagues,[3] provocatively, report that doing small amounts of vigorous intensity physical activity, as little as 1–9 min/week (<1.4 min/day!) vs. none, may lower 5-year mortality risk by nearly 50%. Both studies should be commended for conducting state-of-the-art epidemiological analyses including extensive sensitivity analyses designed to rule out possible biases. Here, we consider both studies in the context of the strengths and potential weaknesses of the analytical methods employed, the value of presenting parallel results for light and moderate intensity activity for comparative purposes, and the ongoing challenge of understanding the accuracy of accelerometer-based estimates of physical activity.

Dempsey and colleagues[2] asked the question—does moderate to vigorous intensity activity alone lower CVD risk, over and above its contribution to total PAEE? Using wrist-worn accelerometer data, they estimated total PAEE (kJ/kg/day) using a prediction model calibrated to strong criterion measures with demonstrated accuracy in a rigorous validation study.[4] To test their hypotheses, they fit PAEE and the proportion of PAEE derived from moderate to vigorous intensity activity (MVPA%) as independent variables and examined their interaction. PAEE and MVPA% were both significantly associated with lower CVD risk. Adults recording a PAEE of 40 kJ/kg/day had a 29% lower risk vs. a PAEE of 15 kJ/kg/day. Compared with adults with an MVPA% of 10, adults with an MVPA% of 30 had a 34% lower risk. Interaction results suggested that a greater MVPA% was associated with a lower risk at a given level of PAEE.

The authors clearly translated the main result from their models, describing a 14% lower CVD risk 'by converting a 14 min stroll into a 7 min brisk walk'. However, it is important to consider important nuances related to their modelling approach and to consider whether alternative approaches could yield additional useful information. First, interpreting results from MVPA expressed as a percentage of PAEE is less easily translated for public consumption (the authors' supplementary table S3). Second, interpretation of the statistical model employed, which is like the 'multivariate energy density' model used in nutritional epidemiology,[5,6] can be complex. Inclusion of total PAEE in the model to control for its unique health effects can change the interpretation of the model coefficients. In some circumstances, the models generate 'substitution' associations that incorporate the influence of both light and moderate to vigorous intensity PAEE.[5,6] This approach is valuable for understanding the trade-offs between both options for increasing PAEE as this report demonstrates, but it can also produce unexpected results. For example, greater total PAEE was associated with lower CVD risk but the interaction results (the authors' table 3) suggested no benefit for increasing PAEE (up to 40 kJ/kg/day) for those with an MVPA% of 10 (i.e. 90% of PAEE from light intensity). If PAEE independent of intensity prevents CVD, is this finding unexpected? These apparently null associations could simply reflect the expected results from substitution associations when both light and moderate to vigorous intensity PAEE have similarly strong inverse associations.

To gain additional insight for clinical and public health translation, for both the hares and tortoises in the population, utilizing a broader range of analytical approaches can provide valuable complementary information.[5,6] For example, 'partition' models[6,7] which in this case would simply partition PAEE into its light and moderate to vigorous intensity components, would estimate associations for a 1 kJ/kg/day increase in both intensity types, with mutual adjustment for PAEE from each. The result from this model defines and can be reformulated to estimate substitution associations.[7] Inverse mortality associations for both light and moderate to vigorous intensity activity duration[8] and volume[9]

The opinions expressed in this article are not necessarily those of the Editors of the *European Heart Journal* or of the European Society of Cardiology.

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have been reported using this approach. Simple joint classifications of each intensity class can also be informative, with some evidence for comparable CVD mortality risk reduction for high levels of either moderate or vigorous intensity activity.[10] Dempsey and colleagues[2] provide novel insights using established measurement methods suggesting that the hare may edge out the tortoise in the race for CVD prevention. However, a more complete picture of both lower and higher intensity activity in parallel in relation to CVD risk would be valuable to extend their findings for translational purposes.

Ahmadi and colleagues,[3] in one of the earliest studies to investigate vigorous intensity physical activity and disease risk, asked the question—is time spent in vigorous intensity physical activity independently associated with lower risk for early mortality, CVD, and cancer? In their comprehensive dose–response analysis, they report the 'minimum' (50% of the lowest risk) and 'optimal' (lowest risk) dose of vigorous intensity physical activity for these outcomes. Substitution type models in the time domain like those described above were employed, including adjustment for total wear time, and light and moderate intensity duration, while examining associations for vigorous intensity duration and frequency. The results indicated significantly lower risk for all-cause mortality and incident CVD and cancer for a minimum dose of 12–15 min/week (15–18% lower risk) and optimal doses ranging from 46 to 57 min/week (31–36% lower risk) for these outcomes. A minimum frequency of 10 bouts/week, 92% of which lasted for ≤1 min, was associated with 16–17% lower risk of incident CVD and cancer. The authors suggest that these results 'provide translation-ready vigorous physical activity findings for public health guidelines and preventive care practice'. We agree that their findings suggest truly remarkable benefits for very small amounts of higher intensity physical activity and, if true, the hare would clearly win the race.

However, public health guidelines and clinical practice require a strong and consistent evidence base from multiple studies using different methods, and it is not uncommon for the earliest findings to overstate the strength of associations observed.[11] While we cannot discern the true strength of association for a given amount of vigorous intensity activity, we see at least two challenges in interpreting the results. First, 3.5% of the population recorded no vigorous intensity physical activity and they were clearly at much higher risk for all outcomes (the authors' table 2 and figure 3). Whether or not these adults could engage in vigorous intensity activity is an open question, but, if they were incapable, it raises the question of whether they should be included in the analysis. Excluding this group from analysis may still reveal significant associations for vigorous intensity activity, but the amount of risk reduction at a given dose of vigorous activity may differ.

Second, in contrast to Dempsey and colleagues,[2] who used a PAEE prediction method that was developed and tested as recommended to demonstrate validity of such methods,[12] the Ahmadi study employed a novel but less established algorithm. The method was calibrated to estimate vigorous intensity activity by distinguishing between only two types of behaviour, walking and running.[13] Several potentially high-quality validation analyses were included (the authors' supplementary text 1), but with limited details provided it was difficult to assess the validity of the duration and frequency metrics employed, and the extent of other vigorous intensity activities not captured by the algorithm (e.g. cycling, swimming, or stair climbing). Furthermore, only 2 h/day of total light and moderate to vigorous intensity activity were reported (the authors' table 1), which is only about a third of the total activity time estimated in UK Biobank studies using different prediction methods, typically 5–6 h/day.[14,15] The possibly limited assessment of total physical activity, coupled with the substitution models fit by Ahmadi and colleagues,[3] opens up the potential for substitution effects from other activity-related behaviours to add to or subtract from the vigorous intensity associations. Substitution effects from sedentary time could add strength to vigorous intensity associations,[7] while unmeasured light and moderate intensity activities could dampen the association. Again, alternative modelling approaches and joint classifications examining associations for moderate and vigorous intensity duration would be valuable to confirm and extend the novel results reported by Ahmadi and colleagues.[3]

Current physical activity recommendations are predicated on the idea that both the hare and the tortoise can win the race for better health, but the provocative studies in this issue of the Journal give an edge to the hare's higher intensity approach. Future studies are needed to examine the consistency of these new findings in other study populations and/or using a range of analytical methods and rigorously developed and validated accelerometer-based prediction algorithms.[12] These will be the critical next steps to build upon the current findings, and hopefully avoid unexpected findings in our race to find a variety of strategies to increase physical activity and prevent CVD and cancer.

Conflict of interest: None declared.

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