COMMENTARY

‘Mean response’ disregards the importance of individual variation

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The conventional approach in the field of exercise science is to report the response to interventions as the mean (average) of the intervention group. While the mean may be a convenient measure, it fails to consider the significant individual variation present in all aspects of human biology, resulting in findings that are at best simplistic and, at worst, misleading.

Several authors have highlighted the discrepancy between the mean group response and the responses of individual participants by reporting the effects of exercise training programmes that were carefully standardised by frequency and intensity of training.[1-6] These standardised training studies have documented a range of responses in parameters, including maximal oxygen uptake (VO_{2max}),[1,3-6] exercise heart rate,[1,5] resting heart rate,[5] individual anaerobic threshold,[5] blood pressure,[1] HDL-cholesterol,[1] resting respiratory exchange ratio (RER),[2] body composition[2] and performance.[6] A particularly interesting example comes from Hautala *et al*.,[3] who measured the change in VO_{2max} after 2 weeks of endurance training. Seventy-three sedentary males and females completed the training, and, while the mean response was an improvement of 8±6%, individual values ranged from a 5% reduction in VO_{2max} to a 22% improvement, with an even distribution of responses in between.

Some may argue that the standard deviation (SD), in this case 6%, is an adequate means of describing the variation in response. In other words, assuming a large sample size and normal sample distribution, 68% of individuals should fall within ±1 SD of the mean or, in this example, between 2% and 14% improvement. There are two potential problems with this approach. The first is that not all readers may be familiar with what constitutes a meaningful difference in a particular measurement and whether the variation should be considered large or small. A 6% difference in performance is most remarkable, whereas a 6% difference in VO_{2max} would be far less so. Secondly, as studies sometimes have small sample sizes for logistical reasons, the data may not adequately represent a normal distribution and the assumptions based on SD are less likely to be accurate.

An important outcome of training studies is to inform effective exercise prescription.[3] Had the authors reported only the mean ±SD, a person adopting a similar training regimen would anticipate an improvement in VO_{2max} of between 2% and 14%. However, there is 32% chance that the individual would fall outside of what is already a considerable range. Specifically, 7% of the participants actually recorded a decrease in VO_{2max}, and 29% either recorded a decrease or did not improve beyond day-to-day variation in VO_{2max}. The consequences of poor response to exercise are particularly concerning when an individual engages in training for health reasons, for example to reduce parameters of cardiovascular risk. In such a case, reporting individual responses would alert to the possibility of the exercise not having the desired outcome.

Another important outcome of training studies is to inform and guide subsequent research. Basing the success of a particular intervention on the mean response is an approach vulnerable to error. Individuals who respond particularly well, or particularly poorly, will skew the mean and influence the ‘effectiveness’ of the intervention. Therefore, avenues of research may be neglected or pursued with misguided enthusiasm when the range in response is not considered. The value of each particular investigation would increase if variation in response was embraced and the ‘poor’ and ‘good’ responders were characterised. However, not all types of research lend themselves to analysis of individual results. Large public health interventions or epidemiological studies with sample sizes of several hundred, for example, can clearly not report individual results. Both large- and smaller-scale studies would be compatible with a ‘probability’-style approach. For example, if 20 moderately trained runners were to complete 8 weeks of hill training, the authors might report that 2 in 3 had a meaningful improvement in 5 km time trial performance, whereas only 1 in 4 had a meaningful improvement in VO_{2max}. This could be further expanded into those who improved time trial performance by <2%, 3 - 5%, >5%, etc., using the author’s discretion. This type of method would go some way to encompassing the individual variation, relative effectiveness and potential for non-response that are so important when evaluating an intervention.

Although mean responses, general categories and blanket recommendations may be easier to work with, they are not necessarily realistic. Authors are therefore encouraged to report their data as thoroughly as possible and make allowance for individual variation when forming their conclusions. A healthy balance between accessibility, in the form of mean values, and accuracy, in the form of individual values, can only benefit researcher and reader alike.

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