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Longitudinal Changes in Cardiorespiratory Fitness: Measurement Error or True Change

Dear Editor-in-Chief,

Jackson et al. (3) showed that 13%–33% of the variance in longitudinal changes in cardiorespiratory fitness were related to physical activity, heart rate, and body mass index and thus cannot be simply due to measurement error. These percentages are germane to the interpretation of the widely cited study by Blair et al. (1) that compared of the risk of dying during 5.1 yr of follow-up to changes in fitness that occurred between two baseline fitness tests that were 4.9 yr apart. Blair et al. reported that men who were unfit (<20% of the fitness distribution) on the first baseline survey and reclassified as fit (>20%) on the second baseline survey had a relative risk of dying (0.56) that was intermediate to men who remained consistently unfit (1.0) or consistently fit (0.33) during follow-up.

Jackson et al. mistakenly assert that their observations refute my demonstration that measurement error alone would account for the significant reduction in risk in men who were reclassified from unfit to fit (4). Their error lies in their assertion that my results apply only when measurement error alone explains the fitness change between surveys. Under the null hypothesis, it is necessarily required that the change in fitness does not affect risk. A change in fitness that has no impact on disease risk is indistinguishable from the effects of measurement error. Even if all of the reclassification in fitness were due to true changes in fitness, but the change in fitness had no effect on risk, then my simulation results would hold exactly, and the conclusion of statistical artifact would remain valid.

Figure 1 presents the expected risk reductions under the alternative hypothesis assuming that changes in fitness affect risk; that is, where the risk during follow-up is

defined by the fitness at the second baseline visit and the cross-sectional relationship between fitness and mortality [(2) or Fig. 3 in (4)]. The relative risks for total mortality reported by Blair et al. (1) for men reclassified from unfit to fit (0.56, 95% confidence interval 0.41–0.75) or fit to unfit (0.52, 95% confidence interval 0.38–0.70) are more consistent with the null hypothesis [0.57 (4)] than the alternatives (0.48 and 0.67, respectively) assuming 57% of the variance in change in fitness was real (see figure, calculated from a correlation of 0.86 between fitness measurements and an R^2 of 33% reported by Jackson et al.). The relative risk for cardiovascular mortality for men reclassified from unfit to fit (0.48, 95% confidence interval 0.31–0.74) or fit to unfit (0.43, 95% confidence interval 0.28–0.67) are also more consistent with the null hypothesis [0.52 (4)] than the alternatives (0.41 and 0.63, respectively). The 95% confidence intervals provide little statistical power for distinguishing between the null and alternative hypotheses. Thus application of the data presented by Jackson et al. (3) to our simulation of the alternative hypothesis further substantiates my attribution of Aerobic Center Longitudinal Study results for change in fitness to statistical artifact alone.

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Figure 1. The relative risk for total (top) and cardiovascular mortality (bottom) under the alternative hypothesis; i.e., changes in fitness produce the mortality corresponding to the second fitness measure (2). Y-axis is the calculated relative risk using consistently unfit as the referent group. The X-axis is the percentage of variance of the difference between the first and second fitness measurement that is due to true changes in fitness (e.g., 0% all measurement error and 100% all true fitness change). Zero percent fitness gives the same result as the null hypothesis at any percent fitness.