EDITORIAL

Physical Activity and Health: What Is the Best Dose?

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Clinicians and scientists have known for a long time of the many health benefits obtained by regularly performing physical activity (PA). Studies by Morris and colleagues[1,2] 50 to 60 years ago showed that male workers in occupations requiring them to be physically active had significantly lower rates of coronary heart disease in middle age than those with sedentary occupations. The research evidence base grew substantially over the years, leading to 2 major public health statements promoting the importance of PA for health and the American Heart Association adding physical inactivity to the major risk factor list in the 1990s.[3–5] In 2008, the first federal Physical Activity Guidelines were issued based on evidence that engaging in 150 minutes per week of moderate-intensity PA or 75 minutes per week of vigorous-intensity PA would result in substantial health benefits.[6] This recommendation implies that the total volume of PA, regardless of whether it is performed at moderate or vigorous intensity, is the key for stimulating health benefits. The study by Shiroma and colleagues[7] in this issue of *JAHA* used an epidemiological approach to evaluate whether there were differences in mortality rates based on the proportion of total PA volume obtained with moderate or vigorous intensity. This experienced author group used data provided by 2 major cohorts, the Harvard Alumni Health Study and the Women's Health Study, each of which has brought us a wealth of evidence of factors associated with health, including PA. They report that the most active men and women had mortality rates 36% to 55% lower than those who were least active and that there was a modest (4% to 10%) additional benefit for men if a greater proportion of the total PA volume was of vigorous intensity.

The primary purpose of the study by Shiroma et al was to evaluate whether PA intensity had a differential effect on health benefits (mortality rates). This is important because, as they pointed out, our current understanding of the role of intensity is limited to a small number of epidemiological studies that have controlled for total PA volume. Their approach to investigating the role of intensity on health benefits, controlled for total volume, is a clear study strength; however, some challenges within their study design and data set should be considered to truly understand the role of PA intensity. These include the representativeness of the populations studied, the method of PA assessment, and the evaluation of health benefit only in terms of mortality.

There are always some considerations regarding the representativeness of the subjects for the general population in any epidemiological study. Participants in both the Harvard Alumni Health Study and the Women's Health Study were predominantly white, likely with an older average age, higher levels of education, and higher socioeconomic status than a general population. These factors may affect mortality rates or effects of PA on mortality. In this study, the representativeness of these cohorts' PA habits need to be considered in comparison to a US adult population. Because PA intensity was the key variable, it is important to consider the subjects' habits with regard to both total PA and amounts obtained at vigorous intensity. Total volume was determined by calculating metabolic equivalent (MET) hours per week (MET-h/week) to equate with the targets recommended in the Physical Activity Guidelines. This method uses the absolute intensity values of 3 and 6 METs as the thresholds for achieving moderate and vigorous intensity, respectively. The Physical Activity Guidelines explain that 150 minutes per week of moderate-intensity PA (using a value of 3.3 METs, the level associated with a brisk [3 miles per hour] walking pace) would equate to a volume of 500 MET minutes per week (or 8.3 [500/60 minutes] MET-h/week). Shiroma et al used 3 versus 3.3 METs for moderate intensity, and 7.5 MET-h/week was set as the lower limit for meeting the recommendations. Consequently, performing vigorous-intensity PA (6 METs) for 75 minutes per week would also be 7.5 MET-h/week. The men evaluated from the Harvard Alumni Health Study were

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reported to have a median value of 18.6 MET-h/week, which is 2.5 times the recommended PA volume in the Physical Activity Guidelines. The 75th percentile for these men was 37.4 MET-h/week, or ≈5 times the recommended volume. Indeed, almost three quarters of the men were meeting the recommendations of the Physical Activity Guidelines. The values for the women evaluated from the Women's Health Study also showed that a majority were meeting the Physical Activity Guidelines, as noted by a median value of 8.4 MET-h/week, with 25% of them averaging 20.5 MET-h/week, 2.7 times the recommended PA volume. Data from Hughes et al[8] report that only 27% of adults aged ≥60 years met the recommendation of 150 minutes per week (34% of men, 22% of women) in the 1999–2004 survey period of the National Health and Nutrition Examination Survey (NHANES). It is clear that the subjects in the Harvard Alumni Health Study and the Women's Health Study were more active than the general US population, especially the men.

Another concern related to the PA profile of this subject group was noted in the groupings of the proportion of total PA performed at vigorous intensity. The authors acknowledged that the lack of additional mortality benefit in women could be attributed to the differences in the PA profiles of the men and the women, particularly because the subgroup of women with the highest percentage of vigorous-intensity PA to total PA actually had a distinctly lower volume (1.6 MET-h/week) than the other subgroups and was well below the recommendation in the Physical Activity Guidelines. The issue of the high total PA level and the pattern of accrual of vigorous-intensity PA may affect the generalizability of the findings. As the authors note, it may be that moderate and vigorous intensities have different health effects at lower levels of total PA. They make this observation because the women, with lower overall total PA levels, saw no additional benefit from vigorous-intensity PA, whereas the men (with higher total PA volume) did; however, the older age of men at the study start and the significantly higher mortality rates for men (3551 of 7979, 44.5%) than for women (1992 of 38 761, 5.1%) warrant caution when comparing the differences seen in the men and the women.

A major issue with any study of the influence of PA is how it is assessed. A recent scientific statement from the American Heart Association provided an extensive overview of PA assessment methodologies that included a summary table of strengths and weaknesses.[9] The study by Shiroma et al used a recall questionnaire method, as is common in most epidemiological studies. The authors cite literature supporting moderate or high test–retest reliability and correlations with their questionnaire to activity recalls and diaries. In addition, previous studies they cited found moderately high correlations of the questionnaire to doubly labeled water, providing support that the questionnaire may provide acceptable measures of total PA. The authors, however, also acknowledged a recent study showing that self-reported assessments of PA do not compare favorably with accelerometer-assessed values for either moderate (r=0.23) or vigorous (r=0.36) intensities of PA.[10] An additional limitation of the questionnaire used in the study by Shiroma et al is that it asked about 3 PA constructs, the first 2 of which we would consider less structured and more incidental activities: (1) city blocks of walking, (2) flights of stairs climbed, and (3) sports and recreational activities. The American Heart Association statement specifically notes that sporadic or incidental PA is recalled with low validity, potentially leading to high levels of misclassification of PA, especially with regard to specific intensity of PA.[9] It is well understood that random misclassification of a variable often weakens associations of this variable with any outcomes (eg, mortality).[11] Consequently, the lack of differences in the health benefits of moderate- and vigorous-intensity PA seen in the study by Shiroma et al may be due to misclassification of intensity by the questionnaire, which would bias results toward a null finding (ie, moderate- and vigorous-intensity PAs are no different in their health benefits).

Objective measures of PA, such as pedometers and accelerometers, are preferable for use over questionnaires when measurement validity is desired. Use of high-validity measurement instruments often results in stronger associations with health indices, for the reasons described. This concept was demonstrated in a recent study by Celis-Morales et al,[12] who showed stronger, more consistent associations of accelerometry-measured PA and sedentary behavior with several health indices compared with use of a questionnaire. In addition, pedometers and especially accelerometers are well suited for capturing sporadic activities as well as planned PA, and their objectivity is a significant advantage compared with the recall bias commonly associated with questionnaires. Accelerometers have not typically been used in large studies because of their cost, limited capacity to capture data for long periods of time, and limited ability to accurately capture nonambulatory activities or activities of daily living (ie, cycling, household chores). Advances in accelerometer technology and methodology have improved their measurement accuracy in a variety of settings and allowed for use in large data-collection efforts such as NHANES. As accelerometer methodologies continue to be refined and improved, their use in epidemiological studies has the potential to vastly improve our knowledge of specific dimensions of PA (eg, intensity, duration, frequency) and associated health benefits. Combined use of self-report and accelerometry may yield even more useful data by being able to capitalize on each method's advantages and minimize their shortcomings.

Given some of the issues cited concerning the representativeness of the PA profile of the cohorts studied by Shiroma

et al and the limitations in sensitivity of the methods to differentiate between moderate and vigorous activity, the reported modest additional benefit for men of vigorous-intensity activity may be questioned. The small additional benefit in only men led the authors to conclude "a focus on moderate-intensity PA is appropriate." They based this conclusion on their mortality data and a 2011 meta-analysis that showed no difference in mortality rates between equal volumes (meeting Physical Activity Guideline recommendations) of moderate versus vigorous intensity. Other literature supports a potential additional value for vigorous-intensity PA. An excellent resource is a 2006 review paper that found lower risk of mortality and better improvements in cardiorespiratory fitness, diastolic blood pressure, and glucose control with vigorous- versus moderate-intensity PA when controlling for total energy expenditure (another common measure of PA volume).[13] Interestingly, this review considered both epidemiological studies (mortality) and clinical exercise training studies (cardiovascular risk factors) and found greater benefit for vigorous-intensity exercise, at equivalent total PA volume, for both types of studies. Although the issue of controlling for total volume of PA is lacking in some clinical training studies comparing various exercise intensities, an abundant body of literature suggests that equal or superior health benefits are derived from vigorous-intensity PA.[14] An area that seems to be gaining much interest, related to promising findings, is consideration of high-intensity interval training as an alternative approach to derive health benefits. A recent meta-analysis reported that this form of training, either as the sole form of training or in combination with continuous training programs, showed much larger-magnitude increases in cardiorespiratory fitness (maximum oxygen consumption increases of 0.5 to 1.0 L/min) than traditional exercise training programs in previously sedentary adults.[15] Another recent high-intensity interval training study showed benefits in cardiorespiratory fitness, glucose control, blood pressure, blood lipids, and body fat.[16] The most interesting aspect of this study was the benefit for cardiorespiratory fitness, glucose control, and blood pressure obtained in 10 weeks with as little as one 4-minute bout exercising at 90% of maximal heart rate for 3 days per week. For these subjects, the total weekly training volume was ≈2 MET-h/week. This relatively low total volume is a characteristic feature of most high-intensity interval-training protocols. High-intensity interval training has been shown to provide benefit in a wide variety of populations including many disease-based groups.[17] Despite the lack of consistent findings of additional mortality benefits for the subjects in the study by Shiroma et al, it appears that performing vigorous-intensity PA can provide a number of health benefits.

The questions remain, what dose of PA will provide health benefits, and is there an additional benefit for those who choose to perform the activity at vigorous intensity? Shiroma et al provide strong support that achieving either the moderate- or vigorous-intensity targets recommended in the current Physical Activity Guidelines will delay mortality in older adults. The evidence-base supporting a wide variety of health benefits for this total volume of PA is conclusive. Studies seeking to tease out whether vigorous-intensity PA may provide additional or superior benefits are far from providing clear answers. In addition to taking individual health history, risk factors, current PA level, and interests into account, clinicians and allied health professionals should be strongly advocating that everyone strive to accumulate at least 500 MET minutes per week in PA of moderate to vigorous intensity.

Disclosures

None.

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