Jae, S. Y., Bunsawat, K., Kurl, S., Kunutsor, S. K., Fernhall, B., Franklin, B. A., & Laukkanen, J. (2021). Cardiorespiratory Fitness Attenuates the Increased Risk of Sudden Cardiac Death Associated with Low Socioeconomic Status. *American Journal of Cardiology*, 145, 164-165. <https://doi.org/10.1016/j.amjcard.2021.01.012>

Peer reviewed version

License (if available):
CC BY-NC-ND

Link to published version (if available):
[10.1016/j.amjcard.2021.01.012](https://doi.org/10.1016/j.amjcard.2021.01.012)

[Link to publication record in Explore Bristol Research](#)
PDF-document

This is the author accepted manuscript (AAM). The final published version (version of record) is available online via Elsevier at <https://doi.org/10.1016/j.amjcard.2021.01.012>. Please refer to any applicable terms of use of the publisher.

University of Bristol - Explore Bristol Research

General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available:
<http://www.bristol.ac.uk/red/research-policy/pure/user-guides/ebr-terms/>

**Cardiorespiratory Fitness Attenuates the Increased Risk of Sudden Cardiac Death
Associated with Low Socioeconomic Status**

Emerging evidence suggests an inverse association between socioeconomic status (SES) and adverse cardiovascular disease (CVD) outcomes that is attributed primarily to poor lifestyle behaviors.¹ More recently, lower SES has been associated with an increased incidence of sudden cardiac death (SCD), an enormous public health concern that accounts for ~50% of all coronary heart disease-related death.² Cardiorespiratory fitness (CRF), which represents an integrity of cardiopulmonary and muscular system to perform and sustain physical activity, is independently associated with CVD risk factors and outcomes.³ Importantly, higher CRF has been demonstrated to exert a favorable effect on the incidence of SCD, independently of potential CVD-related confounders,⁴ but whether CRF also attenuates the incidence of SCD among underserved populations remains unclear. Thus, this prospective study tested the hypothesis that SES and CRF are independently associated with the incidence of SCD and that CRF attenuates the association between SES and the incidence of SCD.

This prospective study was based on a population-based sample of 2,368 men, aged 42 to 61 years, who were followed in the Kuopio Ischemic Heart Disease (KIHD) cohort. The KIHD study protocol was approved by the Research Ethics Committee of the University of Eastern Finland. SES was characterized using self-reported questionnaires via combined measures of income, education, occupation, occupational prestige, material standard of living, and housing conditions, and was categorized into tertiles as well as low SES and high SES based on median values. CRF was directly measured by peak oxygen uptake (VO_{2peak}) during progressive exercise testing to volitional fatigue. CRF was classified by tertiles of VO_{2peak} value based on age-specified CRF categories: low (22.2 ± 4.7 ml/kg per min), moderate (29.9 ± 3.2 ml/kg per min) and high (38.1 ± 5.5 ml/kg per min) as well as into unfit (24.3 ± 5.1 ml/kg per min) and fit (36.0 ± 5.8 ml/kg per min) categories based on median values of age-specific VO_{2peak} percentiles. The joint associations of SES and CRF with SCD were based on the following four

possible combinations (High SES-Fit, Low SES-Fit, High SES-Unfit, and Low SES-Unfit).

SCD was defined as a fatal event that occurred within 1 hour after the onset of symptoms or within 24 hours when autopsy data did not reveal a non-cardiac cause of SCD or after a fatal cardiac arrest following successful resuscitation from ventricular tachycardia and/or ventricular fibrillation. Data on SCDs were derived from interviews with family members, hospital records, death certificates, autopsy reports and medico-legal documents. We used Cox proportional hazard models adjusted for potential confounders to determine the hazard ratios (HRs) and 95% confidence intervals (CIs) of SCD according to each exposure.

During a 27.6-year median follow-up, 268 SCD occurred. After adjusting for confounding factors (model 1), men with low SES were at increased risk for SCD (HR 1.38, 95% CI: 1.02-1.87), but this association was attenuated (HR 1.33, 0.98-1.80) when additionally adjusted for CRF (model 2). Higher levels of CRF were associated with lower risk of SCD (HR 0.66, 0.46-0.95) after adjusting for potential confounders including SES. In joint associations of SES and CRF with SCD, low SES-Unfit had significantly higher risk of SCD (HR 2.04, 1.37-3.02), but low SES-Fit was not significantly associated with an increased risk of SCD (1.41, 0.92-2.16), compared with their high SES-Fit counterparts.

The major findings of this prospective study were that both low SES and high CRF were significantly and independently associated with a higher and lower incidence of SCD, respectively, and that the association between SES and SCD was dependent on CRF. Most importantly, the novel findings of this prospective study were that the incidence of SCD associated with low SES was the highest in unfit men, while the incidence of SCD was significantly attenuated in fit men with low SES. Taken together, these findings from this prospective study extend the favorable impact of CRF on survival outcomes in socioeconomically disadvantaged populations, consistent with findings from a previous study,

which found that moderate-to-high levels of CRF attenuate the incidence of CVD mortality in men with low SES.⁵

Lifestyle risk factors and disadvantaged neighborhood infrastructure may be implicated in the incidence of SCD in underserved populations,^{1,2} thereby underscoring the need for policies and programs focused on modifying lifestyle risk factors that are associated with low SES in order to lower the incidence of SCD¹. Furthermore, the levels of leisure-time physical activity appear to be relatively low in individuals with low SES,⁶ suggesting that SES-related inequalities in physical activity levels may stem, in part, from differences in lifestyle behavior. Thus, our findings that CRF attenuated the incidence of SCD in men with low SES highlight that importance of enhancing physical activity levels due to its widespread benefits and inherently inexpensive nature as a strategy for lowering the incidence of SCD, thereby improving survival outcomes in underserved populations.¹

There is a methodologic limitation to be acknowledged in this prospective study. First, this prospective study included only middle-aged Caucasian men, thus limiting the generalizability of our findings to women, other race/ethnicity, and age groups. Nevertheless, the strength of this prospective study was the use of directly measured peak oxygen consumption using metabolic gas analysis, which provides an objective and quantitative measure of CRF.

In conclusion, SES and CRF are independently associated with the incidence of SCD and that high levels of CRF modifies the association between SES and the incidence of SCD in the general population.

Disclosures

The authors declare that they have no known competing financial interests or personal relations that could have appeared to influence the work reported in this study.

Acknowledgments

Our gratitude is extended to the team of the of the Kuopio Research Institute of Exercise Medicine and the Research Institute of Public Health and University of Kuopio, Finland, for the collection and provision of the data for this study.

Reference

1. Schultz WM, Kelli HM, Lisko JC, et al. Socioeconomic Status and Cardiovascular Outcomes: Challenges and Interventions. *Circulation*. 2018;137:2166-2178.
2. Reinier K, Thomas E, Andrusiek DL, et al. Socioeconomic Status and Incidence of Sudden Cardiac Arrest. *CMAJ*. 2011;183:1705-1712.
3. Franklin BA, Kokkinos P, Lavie CJ. Do Not Forget Physical Activity and Cardiorespiratory Fitness. *Am J Cardiol*. 2018;122(10):1797-1799.
4. Jimenez-Pavon D et al. Jiménez-Pavón D, Lavie CJ, Blair SN. The Role of Cardiorespiratory Fitness on the Risk of Sudden Cardiac Death at the Population Level: A Systematic Review and Meta-Analysis of the Available Evidence. *Prog Cardiovasc*. 2019;62:279-287.
5. Jae SY, Kurl S, Bunsawat K, et al. Impact of Cardiorespiratory Fitness on Survival in Men with Low Socioeconomic Status. *Eur J Prev Cardiol*. 2020;3:2047487319901057.
6. Rawal LB, Smith BJ, Quach H, Renato AMN. Physical Activity among Adults with Low Socioeconomic Status Living in Industrialized Countries: A Meta-Ethnographic Approach to Understanding Socioecological Complexities. *J Environ Public Health* 2020;2020:4283027.

Table 1. Individual and joint associations of socioeconomic status and cardiorespiratory fitness with risk of sudden cardiac death

Socioeconomic status (SES)	Events/Total (268/2368)	Model 1 HR (95% CI)	Model 2 HR (95% CI)
High SES	81/961	1 (reference)	1 (reference)
Moderate SES	75/569	1.34 (0.97-1.85)	1.32 (0.95-1.82)
Low SES	112/838	1.38 (1.02-1.87)	1.33 (0.98-1.80)
Cardiorespiratory fitness (CRF)			
Low	132/782	1 (reference)	1 (reference)
Moderate	78/774	0.70 (0.52-0.95)	0.72 (0.53-0.98)
High	58/812	0.64 (0.45-0.93)	0.66 (0.46-0.95)
Combined SES and CRF		*Adjusted HR (95% CI)	
High SES / Fit	42/710	1 (reference)	
Low SES / Fit	46/484	1.41 (0.92-2.16)	
High SES / Unfit	85/624	1.57 (1.06-2.34)	
Low SES / Unfit	95/550	2.04 (1.37-3.02)	

CI, confidence interval; CRF, cardiorespiratory fitness; HR, hazard ratio; SES, socioeconomic status

Model 1: Adjusted for age, smoking, alcohol consumption, body mass index, systolic blood pressure, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, glucose, diabetes, anti-hypertensive medication, family history of coronary heart disease, history of cardiovascular disease, and physical activity. Model 2: adjusted for model 1 plus CRF when SES is exposure or SES when CRF is exposure.

Sae Young Jae, PhD¹, Kanokwan Bunsawat², Sudhir Kurl, MD³, Setor K. Kunutsor, MD^{4,5}, Bo Fernhall⁶, Barry A. Franklin, PhD⁷, Jari A. Laukkanen, MD,^{3,8,9}

¹Department of Sport Science, University of Seoul, Seoul, Republic of Korea; ²Department of Internal Medicine, Division of Geriatrics, University of Utah, Salt Lake City, Utah, USA; ³Institute of Public Health and Clinical Nutrition, University of Eastern Finland, Kuopio, Finland; ⁴National Institute for Health Research Bristol Biomedical Research Centre, University Hospitals Bristol and Weston NHS Foundation Trust and the University of Bristol, Bristol, UK; ⁵Translational Health Sciences, Bristol Medical School, University of Bristol, Learning & Research Building (Level 1), Southmead Hospital, Bristol, UK; ⁶College of Applied Health Science, University of Illinois at Chicago, Chicago, IL, USA. ⁷Preventive Cardiology and Cardiac Rehabilitation, Beaumont Health, Royal Oak, MI, USA; ⁸Institute of Clinical Medicine, Department of Medicine, University of Eastern Finland, Kuopio, Finland; ⁹Central Finland Health Care District Hospital District, Department of Medicine, Jyväskylä, Finland District, Jyväskylä, Finland

Corresponding Author: Sae Young Jae, PhD.

Health and Integrative Physiology Laboratory, Department of Sport Science, University of Seoul. 90 Jeonnong-dong, Dongdaemun-gu, Seoul 130-743, South Korea. E-mail : syjae@uos.ac.kr, Phone : 82-2-6490-2953 Fax: 82-2-6490-5204