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Integrating real-world wearable data into breast cancer risk assessment: Evidence from the *All of Us* Research Program

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Lifestyle and genetic factors are known contributors to breast cancer risk, yet their integration with clinical data into breast cancer risk assessment remains limited. Traditional, self-reported lifestyle measures are subject to recall bias, whereas wearable devices provide objective, continuous measurements of physical activity and sleep behaviors. Using data from the National Institutes of Health *All of Us* Research Program (>633,540 participants), we conducted a retrospective matched case-control study to evaluate the association between objectively captured wearable data and breast cancer risk, and to establish a scalable analytical framework for causal and machine learning modeling. Females diagnosed with breast cancer at age ≥ 50 years with at least five valid weeks of wearable data (≥ 2 days/week) within the five years preceding diagnosis ($n=154$) were each matched to 20 cancer-free controls by date of birth (± 1 year) and availability of wearable data in the same time window. Numerical variables were analyzed using Wilcoxon signed-rank analysis. Average daily steps were lower in cases (6766 ± 3040) compared to controls (7248 ± 3266) ($p=0.011$). Daily light active and very active minutes were both lower in cases (179.8 ± 69.0 , 13.6 ± 13.7) compared to controls (190.2 ± 69.3 , 16.0 ± 16.9) ($p=0.043$, $p<0.001$, respectively). Measures of sleep were not significantly different between cases and controls. As expected, family history of breast cancer was more common among cases ($p<0.001$, chi-square test). These findings highlight the value of continuous real-world lifestyle monitoring and the potential for integrating emerging wearable technologies into breast cancer risk assessment. This project demonstrates the feasibility of leveraging wearable data within the *All of Us* Research Program and the generalizability of our integrated analysis pipeline (survey, EHR, and wearable data) to other diseases and conditions. Future goals include the integration of genomic data, which may further improve the predictive accuracy of risk assessment. As the volume of wearable and genomic data increases with study progression (targeting one million study participants), additional relationships will likely emerge.