PAI Health

Scientific Studies

PAI Health Scientific Studies

PAI Health's technology is rooted in the proven science of cardiorespiratory fitness, one of the leading predictors of longevity and health. PAI (Personal Activity Intelligence) is the first scientifically validated weekly score that prescribes personalized activity levels for optimal health. Researchers used the HUNT Study data to validate PAI. The HUNT Study is one of the largest studies ever conducted.

This digital magazine contains all PAI studies.

Table of Contents

Study Summary– *The American Journal of Medicine*
Personalized Activity Intelligence (PAI) for Prevention of Cardiovascular Disease and Promotion of Physical Activity

The purpose of this study was to derive and validate the single metric of PAI to determine if this activity tracking metric is associated with a lower risk of cardiovascular disease mortality.

The PAI algorithm was derived from the HUNT Fitness Study (initially conducted from 2006-2008). Using data from approximately 4,631 individuals in the HUNT Fitness Study, it was validated in the general HUNT population (39,298 individuals) aged 20-74 years. The PAI scores were separated into three sex-specific groups (≤50, 51-99, and ≥100), plus the inactive group with PAI scores of 0 as a referent. After more than 1 million person years of observations during a mean follow-up time of 26.2 years, there were 10,062 deaths, including 3,867 deaths (2,207 men and 1,660 women) from cardiovascular disease. Men and women with PAI scores greater than or equal to 100 had a 17% and 23% reduced risk of cardiovascular disease mortality respectively, compared with the inactive groups. Participants who did not obtain a PAI score of 100 or more had an increased risk of dying regardless of meeting the physical activity recommendations.

Published in 2016, this study concluded that PAI "may have a huge potential to motivate people to become and stay physically active, as it is an easily understandable and scientifically proven metric that could inform potential users of how much physical activity is needed to reduce the risk of premature cardiovascular disease death."

The major strength of the PAI algorithm lies in its applicability when incorporated in self-monitoring devices that allow for continuous measurement of the heart rate. Future studies are warranted to validate the algorithm against continuous heart rate measurements and ultimately in long term randomized trials to evaluate the effect on cardiorespiratory fitness, cardiovascular risk and adherence to physical activity in diverse populations.

To read the full study, click here.

CLINICAL RESEARCH STUDY

THE AMERICAN JOURNAL of MEDICINE®

Personalized Activity Intelligence (PAI) for Prevention of Cardiovascular Disease and Promotion of Physical Activity

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ABSTRACT

PURPOSE: To derive and validate a single metric of activity tracking that associates with lower risk of cardiovascular disease mortality.

METHODS: We derived an algorithm, Personalized Activity Intelligence (PAI), using the HUNT Fitness Study (n = 4631), and validated it in the general HUNT population (n = 39,298) aged 20-74 years. The PAI was divided into three sex-specific groups (≤50, 51-99, and ≥100), and the inactive group (0 PAI) was used as the referent. Hazard ratios for all-cause and cardiovascular disease mortality were estimated using Cox proportional hazard regressions.

RESULTS: After >1 million person-years of observations during a mean follow-up time of 26.2 (SD 5.9) years, there were 10,062 deaths, including 3867 deaths (2207 men and 1660 women) from cardiovascular disease. Men and women with a PAI level ≥100 had 17% (95% confidence interval [CI], 7%-27%) and 23% (95% CI, 4%-38%) reduced risk of cardiovascular disease mortality, respectively, compared with the inactive groups. Obtaining ≥100 PAI was associated with significantly lower risk for cardiovascular disease mortality in all prespecified age groups, and in participants with known cardiovascular disease risk factors (all *P*-trends <.01). Participants who did not obtain ≥100 PAI had increased risk of dying regardless of meeting the physical activity recommendations.

CONCLUSION: PAI may have a huge potential to motivate people to become and stay physically active, as it is an easily understandable and scientifically proven metric that could inform potential users of how much physical activity is needed to reduce the risk of premature cardiovascular disease death.

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KEYWORDS: Activity tracking; Cardiovascular disease mortality; Physical activity; Prevention

Low levels of physical activity have reached pandemic proportions, contributing to >5 million deaths each year worldwide.[1,2] Inadequate physical activity not only results in increased individual health burden,[3] but also contributes to tremendous health care expenditures for the society.[4,5] Therefore, promotion of physical activity is needed throughout the health care system.[6,7]

Current recommendations of physical activity suggest that adults should engage in at least 150 minutes of moderate-intensity activity or 75 minutes of vigorous-intensity activity per week, or any combination of activity

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Study Summary– *Progress in Cardiovascular Diseases*
Personal Activity Intelligence (PAI), Sedentary Behavior and Cardiovascular Risk Factor Clustering – the HUNT Study

The primary aim of this study was to examine the associations between sedentary behavior (SB) and cardiovascular disease (CVD) risk factor and the potential modifying effect of earning ≥100 weekly PAI in a large population-based cohort of apparently healthy individuals.

Prolonged SB is defined as behavior in a reclined position (i.e., sitting or lying down). It is estimated that the average adult spends 50–60% of their day in SB. SB is linked to risk factors for CVD and all-cause mortality. Previous studies have shown that even in individuals who meet the current physical activity (PA) recommendations, protection from the risks associated with prolonged SB is not guaranteed.

Between October 2006 and June 2008, 50,812 people were invited to participate in the third HUNT study. More than 20,000 were excluded due to various reasons including: history of MI, angina, stroke or DM, use of blood pressure medications, motion impairment, missing values for PAI, sedentary behavior and smoking, missing data on cardiovascular risk factors.

Trained health personnel measured height, weight and BP. The total sitting time during an average day was based on self-reported data. Other health information was obtained to calculate a weekly PAI score for each participant in the study.

Based on the weekly PAI, participants were subdivided into four categories: ≤50 PAI, 51–99 PAI, ≥100 PAI and the inactive group (0 PAI). SB was divided into three sample and sex-specific groups of equal size: ≤4 hours per day (h/d), 5–<7 h/d and ≥7 h/d. Other health data was collected from participants including waist circumference, HDL cholesterol, systolic and diastolic blood pressure, and serum triglycerides (or medication for hypertension, dyslipidemia or diabetes).

The current study demonstrated that obtaining ≥100 PAI per week attenuated the association between CV-RF clustering and prolonged SB across age groups. A weekly PAI score of 100 can be accumulated through various amounts and intensities of PA. Furthermore, a score of 51–99 PAI per week was associated with a lower prevalence of CV-RF clustering across age groups, suggesting a dose–response relationship between PAI and CV-RF clustering. Thus, even a PAI score lower than 100 may be beneficial for health. It has been shown that major health benefits occur between least active and less active individuals so any activity in highly sedentary persons will go a long way.

The study concluded that if enough PAI is earned it eliminates the risk-clustering from SB. Basically, working out adequate amounts throughout the week (earning about 100 PAI or more), even when sitting for about 8 hours per day, still helps to maintain and could even improves your cardiorespiratory health. For individuals earning less than 100 PAI each week, risk clustering was found to increase and was highest among the most inactive.

To read the full study, click here.

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Personal Activity Intelligence (PAI), Sedentary Behavior and Cardiovascular Risk Factor Clustering – the HUNT Study

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ABSTRACT

Prolonged sedentary behavior (SB) positively associates with clustering of risk factors for cardiovascular disease (CVD). The recently developed metric for physical activity (PA) tracking called Personal Activity Intelligence (PAI) takes into account age, sex, resting and maximum heart rate, and a score of ≥100 weekly PAI has been shown to reduce the risk of premature CVD death in healthy as well as individuals with known CVD risk factors, regardless of whether or not the current PA recommendations were met. The aim of the present study was to examine if PAI modifies the associations between SB and CVD risk factor (CV-RF) clustering in a large apparently healthy general population cohort (n = 29,950, aged ≥20 years). Logistic regression revealed that in those with ≥100 weekly PAI, the likelihood of CV-RF clustering prevalence associated with prolonged SB was attenuated across age groups. Monitoring weekly PAI-level could be useful to ensure that people perform enough PA to combat SB's deleterious association with CV-RF.

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Contents

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Back to Table of Contents

Study Summary– *Mayo Clinic Proceedings*
Personal Activity Intelligence and Mortality in Patients with Cardiovascular Disease: the HUNT Study

The objective of this study was to test whether Personal Activity Intelligence (PAI), a personalized metric that measures and tracks physical activity (PA), is associated with all-cause and cardiovascular disease (CVD) mortality in patients with self-reported CVD, and to determine whether these associations change depending on whether contemporary PA recommendations are met.

A total of 3,133 patients with CVD were tracked from the date of participation (between January 1, 1984, and February 28, 1986) until the date of death or the end of follow-up (December 31, 2015). Mean age of participants was 67.7; with 64% men). Participants weekly PAI score was calculated and divided into four groups: 0, ≤50, 51-99, and ≥100.

Two questionnaires were used to identify individuals with CVD, and record participants' sex, age, self-reported health and use of blood pressure-lowering medication. The questionnaires were also used to assess each participant's alcohol consumption, educational level, smoking status, and diabetes status. Trained nurses assess clinical information such as height, weight, resting heart rate, and blood pressure. Participants' BMI was calculated and using those numbers, participants were divided into four BMI categories: less than 18.5, 18.5 to 24.9, 25 to 29.9 and 30 or greater. An additional questionnaire asking participants about physical activity was used to obtain a PAI score.

After a mean follow-up of 12.5 years (39,157 person-years), there were 2,936 deaths (94%), including 1,936 deaths from CVD. Participants with weekly PAI scores of 100 or more had between 24% to 36% lower risk of mortality from CVD and all causes, respectively, compared with the inactive group. Participants had similar risk reductions associated with their weekly PAI scores, regardless of following contemporary PA recommendations or not.

To read the full study, click here.

MAYO CLINIC

ORIGINAL ARTICLE

Personal Activity Intelligence and Mortality in Patients with Cardiovascular Disease: The HUNT Study

Sophie K. Kieffer; Nina Zisko, PhD; Jeff S. Coombes, PhD; Javaid Nauman, PhD; and Ulrik Wisløff, PhD

Abstract

Objective: To test whether Personal Activity Intelligence (PAI), a personalized metric of physical activity (PA) tracking, is associated with all-cause and cardiovascular disease (CVD) mortality in patients with self-reported CVD and to determine whether these associations change depending on whether contemporary PA recommendations are met.

Patients and Methods: A total of 3133 patients with CVD (mean [SD] age, 67.6 [10.3] years; 64% men) were followed from the date of participation in the Nord-Trøndelag Health Study (between January 1, 1984, and February 28, 1986) until the date of death or the end of follow-up (December 31, 2015). The participants' weekly PAI score was calculated and divided into 4 groups (PAI scores of 0, ≤50, 51-99, and ≥100). We used Cox proportional hazards regression models to estimate hazard ratios for CVD and all-cause mortality rates.

Results: After mean follow-up of 12.5 years (39,157 person-years), there were 2936 deaths (94%), including 1936 CVD deaths. Participants with weekly PAI scores of 100 or greater had 36% (95% CI, 21%-48%) and 24% (95% CI, 10%-35%) lower risk of mortality from CVD and all causes, respectively, compared with the inactive group. Participants had similar risk reductions associated with their weekly PAI scores regardless of following contemporary PA recommendations or not.

Conclusion: Obtaining a weekly PAI score of at least 100 was associated with lower mortality risk from CVD and all causes in individuals with CVD regardless of whether the current PA recommendations were met.

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Cardiovascular disease (CVD) is the leading cause of death globally and accounts for approximately 17.5 million deaths every year.[1,2] Physical activity (PA) is a cornerstone in the secondary prevention of CVD and is associated with a lower risk of mortality from CVD and all causes.[3-5] Consequently, individuals are encouraged to perform at least 150 minutes of moderate-intensity PA or 75 minutes of high-intensity PA or a combination of both weekly.[6] Furthermore, there are also suggestions that high-intensity exercise may be superior in improving the heart in health and disease.[7,8]

Unfortunately, although studies support the efficacy of PA recommendations regarding lowering the risk of CVD and all-cause mortality,[3,9] 83% of patients with CVD fail to meet the current PA recommendations.[10-12] Earlier reports have shown significant benefits at PA levels much below the recommended quantity,[3,5,13,14] which challenge the precision of the contemporary PA recommendations. Recently, we developed Personal Activity Intelligence (PAI),[15] a personalized PA metric that considers the individual's sex, age, and resting and maximum heart rate and reflects the body's response to PA by translating heart rate variations, by the mean of heart rate reserves, over a week into a simple and easily understandable score. Obtaining a weekly PAI score of at least 100 was found to be associated with a lower risk of CVD and all-cause mortality in the general population without CVD and to attenuate the association between sedentary behavior and CVD risk factor clustering in healthy individuals,

For editorial comment, see page 1158

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Study Summary– *Progress in Cardiovascular Diseases*

Personal Activity Intelligence (PAI): A new standard in activity tracking for obtaining a healthy cardiorespiratory fitness level and low cardiovascular risk

The objective of this study was to summarize the epidemiological evidence regarding the effects of PAI on health and investigate the association between PAI and CRF in a large, unsettled population of healthy individuals.

Among individuals ranging from the general population to subgroups of patients with cardiovascular disease (CVD), a PAI score ≥100 per week at baseline, an increase in PAI score, and a sustained high PAI score over time were found to delay premature death from CVD and all causes, regardless of whether or not the current PA recommendations were met. Importantly, a PAI score ≥100 at baseline, maintaining ≥100 PAI and an increasing PAI score over time was associated with multiple years of life gained. Moreover, obtaining a weekly PAI ≥100 attenuated the deleterious association between CVD risk factor clustering and prolonged sitting time.

The impact of higher PAI in reducing risk of premature CVD and all-cause mortality, attenuating the deleterious effects of prolonged sedentary time, and improving V02 peak have been well documented in recent years. These findings suggest that PAI may be a useful tool for quantifying the amount of PA needed to produce significant health benefits in individuals in the general population as well as subgroups of patients with CVD.

To read the full study, click here.

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Personal Activity Intelligence (PAI): A new standard in activity tracking for obtaining a healthy cardiorespiratory fitness level and low cardiovascular risk☆

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ABSTRACT

Despite all the evidence of health benefits related to physical activity (PA) and cardiorespiratory fitness (CRF), low levels of PA have reached pandemic proportions, and inactivity is the fourth leading cause of death worldwide. Lack of time, and inability to self-manage are often cited as main barriers to getting adequate PA. Recently, a new personalized metric for PA tracking named Personal Activity Intelligence (PAI) was developed with the aim to make it easier to quantify how much PA per week is needed to reduce the risk of premature mortality from non-communicable diseases. PAI can be integrated in self-assessment heart rate devices and defines a weekly beneficial heart rate pattern during PA by considering the individual's sex, age, and resting and maximal heart rates. Among individuals ranging from the general population to subgroups of patients with cardiovascular disease (CVD), a PAI score ≥100 per week at baseline, an increase in PAI score, and a sustained high PAI score over time were found to delay premature death from CVD and all causes, regardless of whether or not the current PA recommendations were met. Importantly, a PAI score ≥100 at baseline, maintaining ≥100 PAIs and an increasing PAI score over time was associated with multiple years of life gained. Moreover, obtaining a weekly PAI ≥100 attenuated the deleterious association between CVD risk factor clustering and prolonged sitting time. PAI and objectively measured CRF (as indicated by VO_{2peak}) were positively associated in a graded fashion, and individuals with a PAI score between 100 and 150 had expected age and sex specific average VO_{2peak} values. A PAI score ≥100 was associated with higher VO_{2peak} in both men (4.1 $mL \cdot kg^{-1} \cdot min^{-1}$; 95% CI, 3.5 to 4.6) and women (2.9 $mL \cdot kg^{-1} \cdot min^{-1}$; 95% CI, 2.4 to 3.3), compared to the reference group of <100 PAI. The combined analysis of PAI, PA and VO_{2peak} demonstrated that a PAI score ≥100 was associated with high VO_{2peak} values regardless of meeting or not meeting the current PA recommendations. Collectively, these findings suggest that PAI has the potential to be a useful tool to motivate people to become and stay physically active by quantifying the amount of PA needed to produce significant health benefits.

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Contents

Abbreviations and acronyms: CI, Confidence Interval; CRF, Cardiorespiratory Fitness; CVD, Cardiovascular Disease; HTN, Hypertension; HUNT, the Nord-Trøndelag Health Study; NCDs, Non-communicable Diseases; PA, Physical activity; PAI, Personal Activity Intelligence.

☆ Statement of conflict of interest: see page XX.

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Study Summary– *Progress in Cardiovascular Diseases*
Temporal Changes in a Novel Metric of Physical Activity Tracking (Personal Activity Intelligence) and Mortality: the HUNT Study, Norway

The purpose of this study was to prospectively examine the association between change in weekly Personal Activity Intelligence (PAI) scores estimated 10 years apart and risk of mortality from cardiovascular disease (CVD) and all causes. Weekly PAI scores assessed at a single point in time were found to associate with lower risk of premature CVD mortality in the general health population. However, before this study was conducted, the associations between long-term longitudinal changes in weekly PAI scores and mortality had not been explored.

The study included participants aged 20 years and older from Norway who participated in both the first and second HUNT surveys. All participants filled out detailed questionnaires about health and lifestyle and attended clinical examinations for both HUNT surveys. Of the 77,212 subjects who participated in HUNT1, 47,313 also participated in HUNT2. Excluded from this new study were: 5,006 participants with self-reported CVD, 3,537 subjects with somatic disease (moderate or high), 1,677 subjects with motion impairment (moderate or high), and 12,213 subjects with missing values on covariates. The remaining 24,880 participants were included in the study.

Trained nurses performed clinical measurements including; height, weight, blood pressure (BP), and laboratory measurements, such as non-fasting serum concentrations of glucose, triglycerides (TGs), total cholesterol and high-density lipoprotein (HDL) cholesterol. Body Mass Index (BMI) was categorized into four groups, according to the World Health Organization's BMI classifications.

To assess the association between continuous change in PAI and risk of mortality from CVD and all-causes, the differences between obtained PAI in HUNT1 and HUNT2 were estimated, and categorized into groups of 30 PAI to allow for the assessment of the trend. As previous physical fitness has been associated with risk of mortality, researchers assessed linear trends in different sub-groups of obtained PAI in HUNT1 (0 PAI; 1-50 PAI; 51-99 PAI; ≥100 PAI), using a multi-adjusted model.

In this prospective study of healthy men and women, researchers found that an increase in PAI over a 10-year period was associated with lower risk of mortality, and that participants with a weekly PAI score of ≥100 at both time points had the lowest risk of CVD and all-cause mortality.

To read the full study, click here.

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Temporal Changes in a Novel Metric of Physical Activity Tracking (Personal Activity Intelligence) and Mortality: The HUNT Study, Norway☆

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ABSTRACT

Background: Personal Activity Intelligence (PAI) is a novel activity metric that translates heart rate variations during exercise into a weekly score. Weekly PAI scores assessed at a single point in time were found to associate with lower risk of premature cardiovascular disease (CVD) mortality in the general healthy population. However, to date, the associations between long-term longitudinal changes in weekly PAI scores and mortality have not been explored.
Purpose: The aim of the present study was to prospectively examine the association between change in weekly PAI scores estimated 10 years apart, and risk of mortality from CVD and all-causes.
Methods: We performed a prospective cohort study of 11,870 men and 13,010 women without known CVD in Norway. By using data from the Nord-Trøndelag Health Study (HUNT), PAI was estimated twice, ten years apart (HUNT1 1984-86 and HUNT2 1995-97). Mortality was followed-up until December 31, 2015. Adjusted hazard ratios (AHR) and 95% confidence intervals (CI) for death from CVD and all-causes related to temporal changes in PAI were estimated using Cox regression analyses.
Results: During a mean (SD) of 18 (4) years of follow-up, there were 4782 deaths, including 1560 deaths caused by CVD. Multi-adjusted analyses demonstrated that participants achieving a score of ≥100 PAI at both time points had 32% lower risk of CVD mortality (AHR 0.68; CI: 0.54–0.86) for CVD mortality and 20% lower risk of all-cause mortality (AHR 0.80; CI: 71–0.91) compared with participants obtaining <100 weekly PAI at both measurements. For participants having <100 PAI in HUNT1 but ≥100 PAI in HUNT2, the AHRs were 0.87 (CI: 0.74–1.03) for CVD mortality, and 0.86 (CI: 0.79–0.95) for all-cause mortality. We also found an inverse linear relationship between change in PAI and risk of CVD mortality among participants with 0 PAI ($P < 0.01$), and ≤50 PAI ($P = 0.04$) in HUNT1, indicating that an increase in PAI over time is associated with lower risk of mortality. Excluding the first three years of follow-up did not substantially alter the findings. Increasing PAI score from <100 PAI in HUNT1 to ≥100 PAI in HUNT2 was associated with 6.6 years gained lifespan.
Conclusion: Among men and women without known CVD, an increase in PAI score and sustained high PAI score over a 10-year period was associated with lower risk of mortality.

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Abbreviations: BMI, body mass index; BP, blood pressure; CRF, cardiorespiratory fitness; CVD, cardiovascular disease; DM, diabetes mellitus; HDL, high density lipoprotein; HTN, hypertension; HUNT, the Nord-Trøndelag health study; NCD, non-communicable disease; PA, physical activity; PAI, Personal Activity Intelligence; TG, triglyceride.

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Back to Table of Contents

Study Summary – *Progress in Cardiovascular Diseases*
Personal activity intelligence and mortality – Data from the Aerobics Center Longitudinal Study

The purpose of this study was to test whether Personal Activity Intelligence (PAI), a personalized metric that measures and tracks physical activity, is associated with all-cause and cause-specific disease mortality in a large population from the United States.

56,175 participants were tracked, with a median 14.9 years follow-up time, during which there were 3,434 total deaths, 1,258 of which were cardiovascular (CVD) deaths.

Compared to those who were inactive, participants with a baseline weekly 100+ PAI had the following results:

- Lived on average 4.2 years longer
- 21% risk reduction from all-cause mortality
- 30% risk reduction from CVD mortality
- Smokers had 47% lower risk of CVD mortality
- Overweight/obese participants had 36% lower risk of CVD mortality
- Participants with hypertension had 33% lower risk of CVD mortality

The study concluded that maintaining a weekly PAI score of 100 or more was associated with a lower risk of all-cause or CVD mortality consistent with the HUNT Study based on a Norwegian population, suggesting that PAI is relevant across diverse populations.

To read the full stud, click here.

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Original Research

Personal activity intelligence and mortality – Data from the Aerobics Center Longitudinal Study

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ABSTRACT

Importance: Personal activity intelligence (PAI) is a novel activity metric that can be integrated into self-assessment heart rate devices, and translates heart rate variations during exercise into a weekly score. Previous studies relating to PAI have been conducted in the same populations from Norway where the PAI metric has been derived, limiting generalizability of the results.
Objective: To test whether PAI is associated with total and cause-specific mortality in a large cohort from the United States.
Design: Aerobics Center Longitudinal Study (ACLS) – a prospective cohort between January 1974 and December 2002 with a mean follow-up of 14.5 years.
Setting: Population-based.
Participants: 56,175 relatively healthy participants (26.5% women) who underwent extensive preventive medical examinations at Cooper Clinic (Dallas, TX).
Exposure: Personal activity intelligence (PAI) score per week was estimated and divided into 4 groups (PAI scores of 0, ≤50, 51–99, and ≥100).
Main outcomes and measures: Total and cause-specific mortality.
Results: During a median follow-up time of 14.9 (interquartile range, 6.7–21.4) years, there were 3434 total deaths including 1258 cardiovascular (CVD) deaths. Compared with the inactive (0 PAI) group, participants with a baseline weekly ≥100 PAI had lower risk of mortality: adjusted hazard ratio (AHR), 0.79: 95% CI, 0.71–0.87 for all-cause mortality, and AHR, 0.72: 95% CI, 0.60–0.87 for CVD mortality among men; AHR, 0.85: 95% CI, 0.64–1.12 for all-cause mortality, and AHR, 0.48: 95% CI, 0.26–0.91 for CVD mortality among women. For deaths from ischemic heart disease (IHD), PAI score ≥100 was associated with lower risk in both men and women (AHR, 0.70: 95% CI, 0.55–0.88). Obtaining ≥100 weekly PAI was also associated with significantly lower risk of CVD mortality in pre-specified age groups, and in participants with known CVD risk factors. Participants with ≥100 weekly PAI gained 4.2 (95% CI, 3.5–4.6) years of life when compared with those who were inactive at baseline.
Conclusions and relevance: PAI is associated with long-term all-cause, CVD, and IHD, mortality. Clinicians and the general population can incorporate PAI recommendations and thresholds in their physical activity prescriptions

Abbreviations and acronyms: ACLS, Aerobics Center Longitudinal Study; BMI, body mass index; BP, blood pressure; CI, confidence interval; CVD, cardiovascular disease; DBP, diastolic blood pressure; HR, hazard ratio; IHD, ischemic heart disease; PA, physical activity; PAI, personal activity intelligence; SBP, systolic blood pressure.

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Study Summary— Association between Personal Activity Intelligence (PAI) and Body Weight in a Population Free from Cardiovascular Disease — the HUNT study

Personal Activity Intelligence (PAI) is a new metric for physical activity tracking, and is associated with reduced risk of all-cause and cardiovascular mortality. This study prospectively investigated whether PAI is associated with lower body weight gain in a healthy population.

The study included 85,243 participants (40,037 men and 45,206 women) who participated in at least one of three waves of the Trøndelag Health Study (HUNT1: 1984-86, HUNT2: 1995-97, and HUNT3: 2006- 08). Questionnaires were used to estimate PAI, and linear mixed models to examine body weight according to PAI levels at three study waves. Regression analyses were also conducted to assess separate relationships between change in PAI and the combined changes in PAI and physical activity recommendations, according to body weight from HUNT1 to HUNT3.

Compared with HUNT1, body weight was 8.6 and 6.7 kg higher at HUNT3 for men and women, respectively, but was lower among those with ≥200 PAI at HUNT3. For both sexes, a change from inactive (0 PAI) at HUNT1 to ≥100 weekly PAI-score at HUNT2 and HUNT3, and a ≥100 PAI-score at all three occasions were associated with lower body weight gain compared with the reference group (0 PAI at all three waves). Importantly, among both sexes, obtaining ≥100 weekly PAI at HUNT1 and HUNT3 was associated with lower body weight gain regardless of adhering to physical activity guidelines.

Adhering to a high PAI over time may be a useful tool to attenuate excessive body weight gain in a population free from cardiovascular disease.

The study results indicate that individuals may be able to prevent or minimize weight gain by obtaining high PAI scores during a week. The PAI metric may be an appropriate and personalized metric for both healthy people and individuals with excessive body weight to motivate physical activity participation and mitigate weight gain.

To read the full study, click here.

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Research paper

Association between Personal Activity Intelligence (PAI) and body weight in a population free from cardiovascular disease – The HUNT study

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SUMMARY

Background: Personal Activity Intelligence (PAI) is a new metric for physical activity tracking, and is associated with reduced risk of all-cause and cardiovascular mortality. We prospectively investigated whether PAI is associated with lower body weight gain in a healthy population.
Methods: We included 85,243 participants (40,037 men and 45,206 women) who participated in at least one of three waves of the Trøndelag Health Study (HUNT1: 1984-86, HUNT2: 1995-97, and HUNT3: 2006-08). We used questionnaires to estimate PAI, and linear mixed models to examine body weight according to PAI levels at three study waves. We also conducted regression analyses to assess separate relationships between change in PAI and the combined changes in PAI and physical activity recommendations, according to body weight from HUNT1 to HUNT3.
Findings: Compared with HUNT1, body weight was 8.6 and 6.7 kg higher at HUNT3 for men and women, respectively, but was lower among those with ≥200 PAI at HUNT3. For both sexes, a change from inactive (0 PAI) at HUNT1 to ≥100 weekly PAI-score at HUNT2 and HUNT3, and a ≥100 PAI-score at all three occasions were associated with lower body weight gain, compared with the reference group (0 PAI at all three waves). Importantly, among both sexes, obtaining ≥100 weekly PAI at HUNT1 and HUNT3 was associated with lower body weight gain regardless of adhering to physical activity guidelines.
Interpretation: Adhering to a high PAI over time may be a useful tool to attenuate excessive body weight gain in a population free from cardiovascular disease.
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1. Introduction

The number of obese individuals has tripled over the last 50 years, reaching epidemic proportions [1,2]. Data suggest that excessive body weight has contributed to 4·7 million deaths worldwide in 2017, [3] representing a major public health concern. Excessive body weight results from an imbalance between energy intake and expenditure [4]. Therefore, adults are encouraged to limit energy intake, and engage in regular physical activity [1,5]. The current physical activity guidelines for adults consist of 150 to 300 weekly minutes of moderate intensity physical activity, or 75 to 150 weekly minutes of vigorous intensity physical activity, or a combination of both [5,6,7]. Even though meeting these guidelines has been related to lower body weight and improved health outcomes [8–12], adherence remains low [6,13–15]. Indeed, the guidelines define intensity both in relative terms (relative to one's cardiorespiratory capacity) such as

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Study Summary – Hannan et al. BMC Sports Science Medicine and Rehabilitation

Effect of personal activity intelligence (PAI) monitoring in the maintenance phase of cardiac rehabilitation: a mixed methods evaluation

The purpose of this exploratory study was to determine how monitoring (Personal Activity Intelligence) PAI via a (Wearable Physical Activity Monitoring Device) WPAM could increase the amount and/or intensity of physical activity for individuals in the maintenance phase of cardiac rehabilitation (CR). The study also investigated participants' perceptions of this particular approach.

A total of twenty CR participants, both male and female, completed the study. Out of 20 eligible participants between the ages of 18-80 in the maintenance phase of cardiac rehab, 18 were included in the quantitative data, whilst 20 were included in the qualitative. Participants' heart rates were converted to PAI Scores, and they were monitored daily via a WPAM. Participants were blinded to their PAI Scores during the first three weeks of the study, then un-blinded for the remaining three weeks. PAI data was collected daily throughout the six weeks.

Using a concurrent mixed-methods approach, researchers employed thematic framework analysis to identify three global themes including: participants' perceptions about the WPAM, PAI and various factors, including barriers to exercising.

Once participants were educated about PAI and able to view their personal data, motivation to exercise increased and moderate increases were noted. Once "unblinded" and educated about PAI, participants were given access to their individual data. Based on the quantitative data analysis, 89% of the participants increased their PAI Scores, and on average there was a 42% increase in PAI Scores. Additionally, the percentage of participants who achieved 50 PAI or more increased from 39% at three weeks, to 61% at six weeks.

The concept of PAI was described by CR participants as being an "interesting", "beneficial" and "motivating". 80% of participants believed they would continue to use this approach in the long-term, if the functionality and aesthetics of the wearable device were improved upon.

Notably, all participants agreed that they would recommend PAI monitoring to others. Aside from serving as a motivating factor for some, participants cited the tool's capacity to offer individualized data, as a reason for recommendation. Ultimately, this study suggests that monitoring PAI via a WPAM may be a "viable strategy" in the maintenance of exercise adherence for individuals with cardiac rehabilitation.

To read the full study, click here.

Hannan *et al. BMC Sports Sci Med Rehabil* (2021) 13:124
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BMC Sports Science, Medicine and Rehabilitation

RESEARCH ARTICLE Open Access

Effect of personal activity intelligence (PAI) monitoring in the maintenance phase of cardiac rehabilitation: a mixed methods evaluation

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Abstract

Background: Personal activity intelligence (PAI) is a single physical activity metric based upon heart rate responses to physical activity. Maintaining 100 PAI/week is associated with a 25% risk reduction in cardiovascular disease mortality and 50 PAI/week provides 60% of the benefits. The effect of utilising this metric within a cardiac population has not been previously investigated. The aim of this study was to determine the effect of PAI monitoring on the amount and/or intensity of physical activity for people in the maintenance phase of cardiac rehabilitation and to explore participants' perceptions of this approach.

Methods: A concurrent mixed methods approach was undertaken. Participants in the maintenance phase of cardiac rehabilitation monitored PAI for six weeks via a wearable physical activity monitoring device (WPAM). In the first three weeks participants were blinded to their PAI score. A quality-of-life questionnaire (EQ-5D-5L) was completed, and semi-structured interviews conducted to investigate attitudes to PAI monitoring. Daily PAI data was collected throughout the 6-week period.

Results: Twenty participants completed the trial. PAI earned/day was increased after participants could view their data (mean difference: 2.1 PAI/day (95% CI 0.3, 4.0), $p = 0.027$). The median change in percentage of days participants achieved a Total PAI score of 25 ($p = 0.023$) and 50 ($p = 0.015$) were also increased. The mean change in total scores for the EQ-5D-5L and EQVAS were improved after 6 weeks (0.6 ± 1.05; 95% CI (0.11–1.09); $p = 0.019$); (5.8/100; 95% CI (2.4–9.2); $p = 0.002$ respectively). Thematic framework analysis identified three global themes (perceptions on the WPAM, PAI and factors affecting exercise). Most participants stated motivation to exercise increased after they could view their PAI data. Many of the participants believed they would continue to use PAI long-term. Others were undecided; the latter primarily due to technical issues and/or preferring devices with greater functionality and attractiveness. All participants would recommend PAI.

Conclusion: This exploratory study showed monitoring PAI via a WPAM increased the amount and/or intensity of physical activity within the cardiac population. Participants found PAI interesting, beneficial, and motivating. If technical issues, aesthetics, and functionality of the WPAM were improved, participants may continue to use the approach long-term. PAI may be a viable strategy to assist people with cardiac disease maintain physical activity adherence.

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About Professor Ulrik Wisløff, PhD
Head of Cardiac Exercise Research Group and K.G. Jebsen Centre for Exercise in Medicine at NTNU
Inventor of PAI, published author and researcher of the PAI studies

Professor Ulrik Wisløff, PhD, is the head of the Cardiac Exercise Research Group and the inventor of PAI. He is an internationally recognized researcher, professor and entrepreneur in the field of exercise physiology, whose primary appointment is at the Norwegian University of Science and Technology. As of January 2019, he has more than 300 publications, 32,000 citations, an h-index of 73 with a total career grant funding amounting to more than 300,000,000 NOK (ca. 35 000 000 USD).

Dr. Wisløff's work provided the first causative evidence that low exercise capacity per se is sufficient to dramatically increase cardiovascular disease risk. Subsequently, his interest in high intensity training led him to discover that high-intensity exercise is not only safe, but leads to superior improvements in both aerobic capacity and cardiac function in heart failure patients. This line of research formed the basis for Dr. Wisløff's very own research group, which by employing the high-intensity training approach demonstrated optimal results to various lifestyle-related disorders. Considering the tight link between cardiovascular physiology and longevity, Dr. Wisløff used the epidemiological HUNT-studies and showed that simple temporal changes in resting heart rate could predict cardiovascular death. This lead to an establishment of a world fitness level algorithm, which estimates fitness age and thereby predicts death in the general population. Several million people have used this algorithm, with the number of users rising daily.

Dr. Wisløff invented the simple Personalized Activity Intelligence (PAI) metric with the ambition to motivate more people to become sufficiently physically active. PAI calculates how much weekly physical activity one needs to prevent disease and early death, based on individual information about age, sex, resting and maximum heart rate. The PAI metric is compatible for use with popular wearable devices – including Fitbit and Apple Watch.

Importantly, Dr. Wisløff's group, under his exceptional leadership, has translated basic experimental evidence into clinical trials (and patient benefit) within a remarkably short timeframe of 10 years, with research spanning for molecules to society, and back again.