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Internet Use and Circulatory Health: Internet Use Is Associated with Raised Risk in the Young, but Lowered in the Elderly

Hakan LANE[1], Mark David WALKER[2]

Abstract

Today computers are ubiquitous, and both our working and leisure hours are increasingly being spent in sedentary fashion online. Lack of physical activity is a known risk factor for cardiovascular disease, but few studies examine the link between computer use and health. The European Social Science survey questions as to daily internet use, allowing study of the association with cardiovascular problems. Mean daily internet use was compared between those with self-reported heart and circulation problems and high blood pressure and those without. The nature of the relationship was studied with Generalized Additive Modelling (GAM). There was no difference in mean internet use between those with high blood pressure or heart problems and those without. GAM showed the association between internet use and heart problems alters with age; risk was raised in younger ages, but lower when older. BMI was found to be important in mediating the influence of internet use in the young. Socio-economic factors mediated the age effect. The influence of BMI for young ages suggests a link with weight, activity and diet. For older people, the influence of socio-economic factors suggests that the social and cognitive benefits of internet use may offer protection. There may be a link with higher health literacy and thus better heart health. Internet use should be considered a causative risk factor of itself.

Keywords: cardiovascular disease; physical activity; internet use; social media; lifestyle.

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Introduction

The way we live has been fundamentally reshaped by the adoption of digital technologies, with up to 90% of adults using the internet daily, and smartphone ownership continuing to rise across all age groups (Eurostat, 2023). There has been an increase in those working with computers at the expense of traditionally manual occupations, a phenomenon known as the 'sedentary shift' (Church *et al.,* 2011). Additionally, leisure time is increasingly being spent online, particularly for younger age groups, with the rise of Social Media and media content present online such as Netflix (Twenge, 2019).

It seems intuitive that time spent online will be at the expense of time outdoors, engaged in exercise, or being social (Fotheringham *et al.,* 2020) The replacement of such activities with screen time is known as the displacement hypothesis (Neumann, *et al.,* 1988); it is well supported. Kraut *et al.* (1998) found that adoption of the internet led to declines in family communication and increases in 'pseudosocialising.' Time online is at the expense of socialising, sleeping and physical activity (Nie *et al.,* 2002). Studies show that outdoor activity declines with screen time in adolescence (Larson *et al.,* 2008). However, results are mixed, some studies find only a slight association between physical activity and digital use in children (Larsen *et al.,* 2019).

Researchers are interested in whether this shift to more sedentary lifestyles will have a lasting health impact. It is widely accepted that being sedentary leads to worse health (Owen *et al.,* 2010). Much existing research has been on children or adolescents. For example, a link with a sedentary lifestyle, poor diet, and obesity has been found related to television watching (Rosiek *et al.,* 2015). In one notable study high and low internet use groups were compared; the high use group had higher levels of obesity, independant of other factors (Vandelanotte *et al.,* 2009).

Other conditions are less well studied, including cardiovascular diseases (CVDs). CVDs are the leading cause of death globally, accounting for approximately 17.9 million annually (Martin *et al.,* 2025). An important risk factor for CVD is physical exercise (Roth *et al.,* 2020). The importance of physical activity is underlined through current international guidelines emphasizing it as the cornerstone for cardiovascular health (Arnett *et al.,* 2019).

Studying how technology influences heart health is difficult because of the interrelated influence of risk factors. For example, clustering of risk factors pccurs, with most CVD caused by a select group of often co-existing risks (hypertension, diabetes, obesity, diet, physical activity (Yusuf *et al.,* 2016). Isolating the influence of a single risk is problematic because of this confounding. This is relevant as internet use typically varies by age, as do CVD risk factors like activity (Hallal, *et al.* 2016; Sallis, 2000). Disentangling these interrelated variables is thus difficult.

The European Social Survey (ESS, 2025) allows the possibility to investigate internet use and CVD risk. This analysis aims to clarify whether internet use is associated with CVD risk. Few data sources provide information relating to internet use. Existing studies rely on clinical or small-scale datasets, limiting generalisability to broader populations (Schöne *et al*., 2025). Population-based evidence on how daily internet use relates to CVD is scarce.

Research questions are: (1) Is there an association between internet use and CVD? (2) How do patterns of internet use compare with known risk factors for CVD, such as age? (3) Is the relationship between internet use and cardiovascular risk mediated by age, lifestyle, and socioeconomic factors?

Methodology

Data

Data were drawn from the European Social Survey (ESS11, v.4.1), a high-quality, cross-national survey. The analytical sample included adults over 15 from participating European countries.

Variables

The outcome variables (Binary) examined were self-reported presence of (a) High Blood Pressure (*hltprbp*) and (b) a Heart/Circulation Problem (*hltprhc*). The primary predictor was internet use in minutes per day (*net_use*). A theoretically informed set of covariate variables were considered including age and gender (Supplemenetary Material 1). Continuous predictors were capped to remove outliers; internet use was limited to 480 minutes, age to 90 and education to 50 years. BMI was calculated and categorized (underweight, normal, overweight, obese) based on WHO thresholds. Listwise deletion was applied.

Statistical analysis

The association between internet use and cardiovascular disease. Mean internet use was compared between those reporting circulatory problems and those without, stratified by age. Differences were compared with the Wilcoxon rank-sum test.

Patterns of internet use by age, gender and risk factor/ Mean internet use was studied by age and gender and the worst and best percentage of respondents for a variety of CVD risk factors ascertained.

The relationship between internet use and CVD risk. Preliminary logistic regressions were fitted to examine age and to identify potential confounders. These indicated that the effect of age on CVD was non-linear, prompting the use of Generalized Additive Modelling (GAMs) which allows non-linear modelling with spline terms. A baseline model adjusting for age, gender, and country (GAM1) used smooths for net use, age, and their interaction. Subsequent models incorporated established lifestyle (GAM2) and socioeconomic variables (GAM3) to assess how these factors influenced the age-dependent association between internet use and health. Survey weights were incorporated. Models were binomial, with a logic link function. REML was used. Normalized weights (*dweight* and *pweight*) were integrated. A random intercept for country was included to allow study of country-level differences. A series of models were fitted, beginning with demographic predictors and progressing through lifestyle and socioeconomic variables; spline terms were introduced where there were non-linear age effects.

Results

Association between internet use and CVD

Examination of mean daily time on the internet found no notable differences between individals stating heart and circulation problems or high blood pressure and those without (Table 1). Although younger adults reported higher daily internet use than older adults, the differences across age groups were modest. There was higher mean daily use for those with these conditions in the lowest age range, and for those over 60. Only the difference for 19 to 29 years olds for heart and circulation problems was significant (Wilcoxon rank-sum test: $P < 0.05$). There is large within-group variability which suggests substantial heterogeneity in internet behaviour at all ages.

Table 1. Mean daily internet usage by age group. (95 % confidence interval).

Age group	HBP: No	HBP: Yes	Heart/Circ: No	Heart/Circ: Yes
19–29*	257 (254–261)	271 (255–287)	257 (254–261)	281 (260–302)
30–39	216 (212–219)	231 (214–247)	217 (214–220)	206 (188–225)
40–49	195 (192–199)	191 (177–205)	196 (192–199)	183 (167–199)
50–59	173 (170–176)	170 (159–181)	172 (169–175)	175 (164–187)
60–69	142 (139–144)	152 (142–162)	142 (139–145)	146 (139–154)
70–79	118 (114–121)	126 (115–136)	119 (116–123)	116 (110–123)
80–90	110 (104–117)	109 (93–125)	109 (102–116)	113 (100–125)

Patterns of internet use and known CVD risk factors

Regarding gender, a design-based Wilcoxon rank-sum test indicated a statistically significant difference in daily internet use ($t = -2.05$, $df = 30{,}434$, $p = 0.040$). Although significant, the effect size was very small (mean rank score difference = −0.01), suggesting minimal practical difference.

There was a strong relationship between internet use and age (Figure 1). Mean daily internet use was statistically different across ages (Kruskal Wallis. df = 6, Chi2 = 2954.7, p-value < 0.001). Post-hoc Weighted pairwise Wilcoxon tests showed that nearly all age-group pairs differed significantly from each other (p < .001); younger groups consistently report higher internet use.

Figure 1. Weighted mean daily internet use by age group, with 95% confidence intervals.

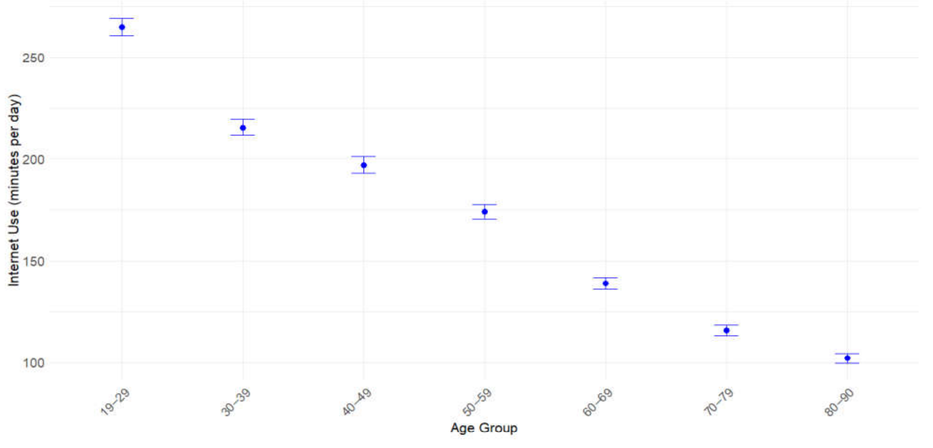

Table 2 shows the percentage difference in internet use between the best and worst scoring participants for a range of risk factors for CVD. Examination of mean internet use across key lifestyle categories is provided (Supplementary Material 2).

Table 2. Percentage difference in number of cases of heart and circulation problems between the highest and lowest risk factor group.

Habit	Tendency	Usage in worst group compared to use in best group
Sleep	Worse	+6.3 %
Vegetable	U shaped	
Fruit	Worse	+18.1 %
Sport	Better	-8 %
Smoking	Better	-10.8 %
Alcohol Frequency	Not significant	
Happiness	Better	-5.3 %
Nutrition	Not significant	

Modeling internet use and CVD risk

Initial modeling examining age identified a significant non-linear interaction with internet use (GAM1) (Figure 2; Table 5). Examination of the interaction between age and internet using the tensor interaction (ti(net_use x agea)) confirms that the relationship between internet use and heart health depends on age (p = 0.013). The Effective Degrees of Freedom (EDF = 5.375) for this interaction indicates it is non-linear. While the main effect of internet use on circulation problems was non-significant (p = 0.914), the interaction suggests that the association between digital behavior and cardiovascular health varies across the life course. In other words higher internet consumption is associated with increased log-odds of heart problems in younger ages, whereas this association flattens or trends slightly negative in those older (Figure 3). There is a 'cross-over' with effects changing through life. The random effect for country was highly significant (chi2 = 253.92, p < .001), indicating substantial geographic variation in heart problem prevalence across Europe.

Table 3. GAM modelling summary and results

	Model Details		Results	
Model	Aim	Model configuration	Key Finding	Conclusion
GAM1. Bivariate Interaction	Baseline: adjusting for age, gender, and country. Smooths for net use, age, and their interaction.	heart problems ~ s(net use) + s(age) + gender + ti(net use, age) + s(country)	Significant ti() interaction.	Identifed a "Digital Crossover". Internet use is a risk for young but protective for old.
GAM2. Lifestyle Models	Adds lifestyle factors in turn (sleep, BMI, fruit intake, physical activity) to GAM1.	Model 1 + lifestyles	Interaction remained significant, but BMI and Sleep emerged as massive direct predictors.	BMI and sleep important. But effect of age remains, signalling is true phenomenon.

GAM3. Global/SES Model	Comprehensive model adding, education, income.	Model 2 + s(income feeling) + s(eduyrs)	The ti() interaction faded (p=.14). Education and Income "soaked up" the elderly benefit.	Shows "protective" effect in seniors was due to their higher wealth/ education.

Integration of different lifestyle risk factors (GAM2) thought likely to be influenced by internet use, demonstrated that this digital crossover effect is not merely a byproduct of lifestyle. Modeling with sleep, fruit and physical activity showed these were significant predictors, but that the age x Internet interaction remained consistent with previous models. Modeling with BMI did lead to lower chi-square values for the interaction between age and internet use than seen when modeling with sleep and fruit. This suggests that the influence of the internet on circulation problems is partially mediated by body mass. In other words, the increased risk seen in younger ages may be due to the physiological impact of BMI. This relationship is 'U' shaped, with Underweight and obese individuals showing elevated risk.

Interaction modeling highlighted the differential vulnerability of specific lifestyle groups regarding cardiovascular risk. While increasing internet use did not noticeably elevate CVD risk for participants across varying levels of physical activity, fruit intake, or sleep quality, a distinct divergence emerged within BMI categories. Specifically, for those in the underweight category, CVD risk increased in a clear linear fashion as internet use intensified. As this demographic may encompass individuals characterized by physical frailty, this unique association suggests that high digital engagement in this group may serve as a proxy for deeper health complications, where increased screen time indicates reduced mobility or being housebound due to comorbid conditions.

The final model (GAM3) incorporated socioeconomic variables and led to anattenuation of the age-internet interaction. This suggests that socioeconomic factors are mediating the age x internet relationship. The previously observed ‚protective' effect observed through internet use in older cohorts may be being driven by selection bias, with those older participants using the internet having higher levels of formal education and being financially secure. Older Internet users may be using the internet for health-seeking behaviors, thereby masking the direct cardiovascular risks seen in younger, more sedentary participants.

Table 4. Full model coefficients from final socioeconomic GAM model (GAM3)

Predictor	Estimate	Std. Error	z value	p
Fixed Effects				
(Intercept)	-2.343	0.137	-17.113	< .001***
Income: Coping	0.015	0.073	0.205	0.838
Income: Difficult	0.353	0.111	3.184	.001**
Income: Very Difficult	0.506	0.196	2.58	.010**
Good Sleep	-0.575	0.073	-7.826	< .001***
Physical Inactivity	0.187	0.069	2.716	.007**
BMI: Underweight	0.435	0.154	2.825	.005**
BMI: Overweight	0.025	0.08	0.315	0.753
BMI: Obese	0.429	0.087	4.944	< .001***
Gender (Female)	-0.004	0.067	-0.061	0.951
Smooth Terms	edf	Ref.df	χ^2	p
s(Internet Use)	3.317	3.966	10.485	.034*
s(Age)	5.083	5.972	268.585	< .001***
ti(Internet x Age)	2.947	3.443	6.999	0.143
s(Education)	1	1	9.041	.003**
s(Country)(RE)	5.41	9	39.017	< .001***

*Note. Significant at: ***p < .001, **p < .01, *p < .05.*

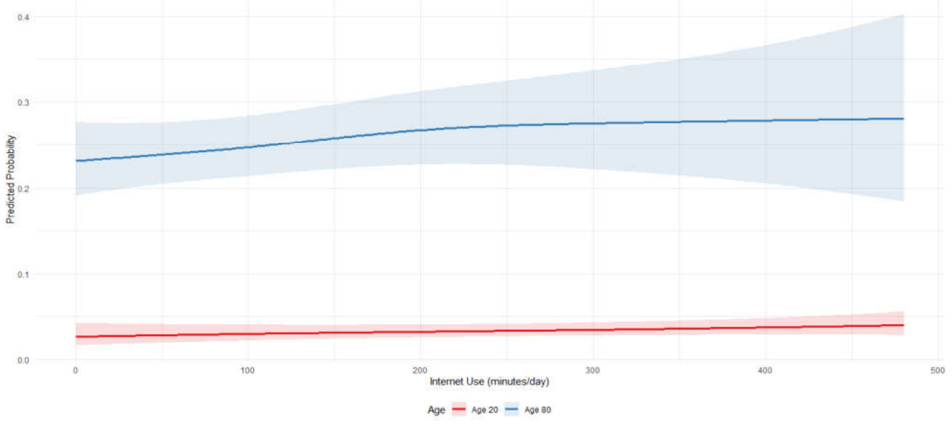

Figure 2. Predicted probability of circulation problems as a function of daily internet use from GAM1. There is a positive risk association for younger ages that is absent for older cohorts.

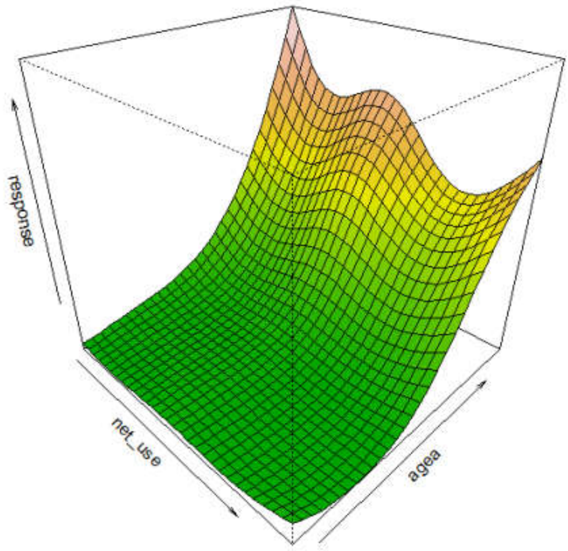

Figure 3. Tensor Product Interaction between daily Internet Use and age on Circulation problems risk (GAM4). Risk increases with age, internet influence alters risk, with increased internet use resulting in lower risk for the oldest.

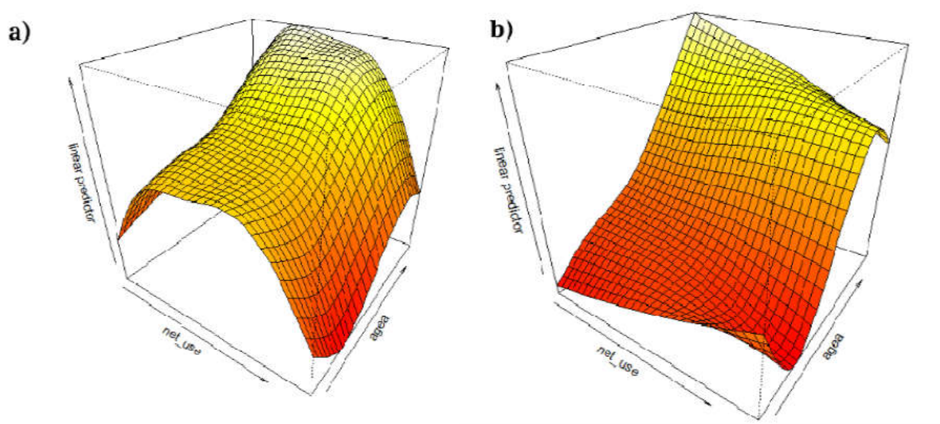

Figure 4. Predicted probability of heart conditions by Internet Use. Comparison of a) Underweight and b) Obese BMI Categories. For the obese, the risk remains high with a flat trajectory, suggesting that for these individuals, the presence of high body mass is the dominant risk factor regardless of internet duration. In contrast, for those Underweight there is a distinct positive linear slope; as internet use increases, predicted probability rises sharply.

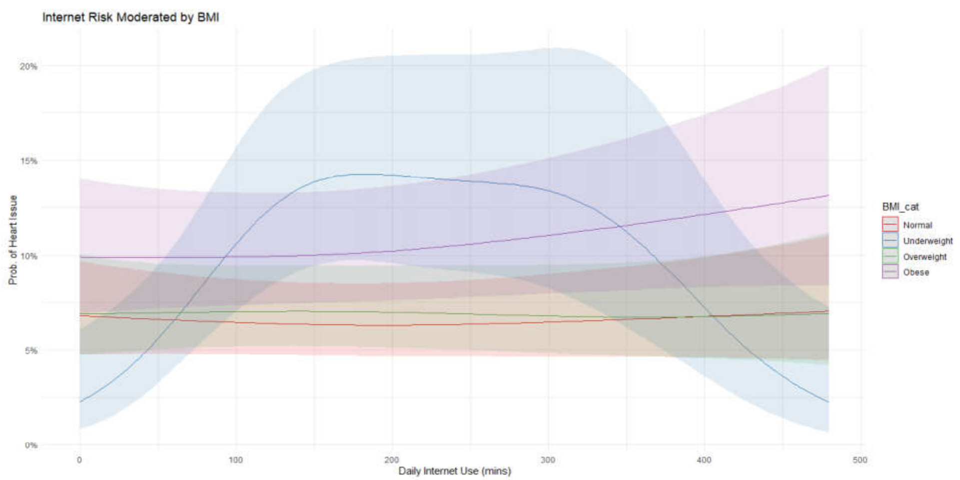

Figure 5. How internet use influences the risk of heart and circulation problems by BMIT category. For 'obese' risks rise rapidly with internet use, for 'underweight' they rise rapidly and then decline.

Discussion

Internet use and heart health: There was little actual difference in the mean time spent online by those with high blood pressure or heart and circulation problems and those without. Generally, time online was slightly higher for those with these conditions in younger age ranges, and slightly lower for older, however this was not consistent or statistically significant for most age groups. This should not be surprising; internet use is only one potential risk factor for these conditions, with other confounding factors, notably age, being of far greater influence and possibly obscuring the effects caused by a more sedentary lifestyle.

Differences in internet use by age and gender: There was great variation in the mean time spent online by different age groups, with younger age ranges typically online to a far greater extent than older. Given that age is the predominant risk factor for heart problems this suggests that any effect of internet use on heart problems needs to consider this confounding effect. No difference was found between the genders.

No consistent pattern was observed in the percentage of heart and circulation problems or high blood pressure in those in the worst category of selected lifestyles, and those in the best.

Relationship between internet use and CVD risk factors: Initial logistic modeling showed no relationship between internet use and heart and circulation problems. Age was the principle risk factor, but the relationship appeared non-linear in nature prompting use of GAM's.

More nuanced GAM modelling showed that the effect of internet use does not follow a single direction; it is a risk for younger cohorts while having a protective association among older. These opposing trends effectively cancel each other out in a simple logistic regression model, accounting for the lack of association seen, but are captured through more complex GAM modeling.

Integration of lifestyles to ascertain which might be accounting for this age relationship found little effect from physical activity, fruit consumption, or sleep. However, BMI was of influence in younger cohorts, showing a clear U-shaped pattern: both underweight and obese individuals had substantially higher odds of reporting heart problems. This suggests both a dietary and physical activity link in the young, as BMI is a result of both these factors, with raised BMI occurring due to poor weight management.

Regardless of the integration of such lifestyles, the age-internet association remained. However, in final modeling integrating socio-economic factors this effect was attenuated. This suggested that in the elderly education plays a part in mediating the relationship. Possible reasons could be that in the elderly the internet offers social and cognitive activity, which is beneficial to health. Internet use in old age is maybe indicative of education attainment or inquisitive in earlier life, with such individuals pursuing a healthly lifestyle over decades.

Digital technology and CVD: Stamatakis *et al.* (2011) used Scottish survey data to examine the relationship between screen time, all cause mortality, and CVD events, concentrating on BMI. Screen use for more than four hours daily was inmportant, independent of physical exercise. Recent research has found higher cardiometabolic risk in children and adolescents with each increasing screen time (Horner *et al.,* 2025).

Studies have shown that internet use is related to better heart health in the elderly (Fox *et al.,* 2016). For example, Richard *et al.* (2019) showed that those enrolled in a health literaty program reduced cardiovascular risk in the elderly.

Risk factors: More common are studies which demonstrate an influence of digital use with key known risk factors for cardiovascular disease, rather than directly between internet use and CVD. Many studies examine physical activity or a sedentary lifestyle. The study by Vandelanotte *et al.* (2009), examined leisure-time internet use and activity; High internet use was strongly associated with weight gain and poor nutrition in younger adults compared to older. Cohen *et al.* (2025) found an association between electronic media use and physical activity. A systematic review demonstrated that higher sedentary time is associated with increased incidence of cardiovascular disease and mortality, even after adjusting for physical activity (Wen *et al.,* 2022). This suggests that behaviours linked to digital engagement may contribute to cardiovascular risk. One recent study examined physical activity and internet use found that in those aged over 35 internet use was associated with increased physical activity, and acting to promote it (Chen *et al.,* 2024). Studies show that the amount of sitting is inversely related to levels of physical activity (Bauman, *et al.,* 2011).

Studies examining other risk factors exist. For example, internet use has been found to damage sleep in young adults (Hale and Guan, 2015). There appears also to be changes in diet; whilst online at home there is easier access to food, and increased tendency to snack. Reducing screen time leads to a corresponding decline in child BMI, due to lower calorie intake rather than increased activity (Epstein *et al*., 2008). An association has been found between screen time and several risk factors for obesity including physical activity and diet (Kenney and Gortmaker 2017). Latent class analysis has been found that screen based sedentary activity is grouped with low physical activity and poor diet (Iannotti & Wang 2018).

There are well established links between heart health and education, and Internet use may be a proxy for this. The internet may be used for health related searching, which is associated with better health, suggesting it is not internet use itself which is a risk, but what it is used for Hunsaker *et al.,* (2021).

More recent research has begun to examine joint and interaction effects of lifestyle behaviours to better capture their combined influence on cardiovascular health. Nagata *et al*. (2022) used data from the Adolescent Brain Cognitive Development Study, and employed a joint categorization approach to analyse the combined associations of physical activity and screen time with cardiovascular risk markers. Their findings showed that low physical activity combined with high screen time was associated with less favourable cardiovascular profiles. It suggests that digital engagement may interact rather than exert purely additive effects. Wu *et al.* (2025) examined social activity and its influence on heart health, with internet use being one of the variables integrated.

Strengths and limitations: The availability of ESS data provided the opportunity to examine the influence of internet use throughout life, meaning subtle differences apparent at different age ranges were seen, which is rare in other studies. The ESS provides data on a wide range of lifestyle attributes, and has been used to identify those most closely associated with cardiovascular risk (Valko, *et al*. 2025).

Most existing studies use standard logistic regression to examine relationships. Use of GAM accounted for the non-linear nature of data better and allowed patterns to become apparent. Although other research has demonstrated a link with poor health in the young, or better in the elderly, few link both.

The main limitation is the broad nature of variable responses available. For example, exercise data is limited to the times each week, with no indication of quality or duration, both which are important in cardiovascular health. Fruit intake was used as a proxy for diet quality. ESS does not question on 'junk food', calorie intake, or snacking.

It must be emphasised that these are associative models, only suggesting causative reasons which require further study to be confirmed. The modelling provides only a 'snapshot' of current health; the influence of lifestyle may become apparent over time. Cardiovascular conditions take time to develop.

Implications: This research has public health implications; advice should be tailored to age, with caution in length of time spent on the internet recommended for younger ages, and emphasis on increasing exercise and a healthy diet. Recommendations to become digitally active for the elderly may provide a protective effect.

Conclusion

In conclusion, this research found age differences in the influence of internet use on heart health, finding a ‚digital crossover' in effects. Final models reveal that the relationship between internet use and heart health is embedded in socioeconomic contexts for the elderly, and potentially diet and activity related factors for the young, expressed through BMI. Consequently, while high-frequency digital use may pose a sedentary risk for younger ages, it serves as a critical medium for health literacy and social connectivity in later life, provided the individual possesses the socioeconomic resources to navigate it effectively.

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