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Video gaming and its impact on driving simulation performance: A secondary analysis of a randomized control trial

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Abstract

Background: Individuals who play video games on computers and cellphones may have better psychomotor skills. It is unknown whether simulated driving performance varies between individuals who play video games more per week compared to individuals who play less. This study investigates whether initial simulated driving performance differs between high and low gamers during a brief (e.g., 10 minutes) driving simulation. *Methods:* Data for this study were collected at baseline during enrollment for a randomized clinical trial ($n = 40$). Participants playing video games for > 10 hours/week were categorized as the high gaming group; others were in the low gaming group. Each participant drove the same simulation on the STISIM M1000 simulator, which recorded various driving performance metrics (e.g., driving out of lane and time to initial collision). Data between the groups were compared using Cox proportional hazards and analysis of covariance regression models. *Results:* The average age of participants was 21 ± 2.7 years and 48% were male. After adjusting for age, sex, and miles driven per week, the high gaming group spent a mean 4% less time driving out of lane compared to the low gaming group ($\beta = -4.03$, SD = 1.32, $p \leq 0.05$). No other differences were observed between groups for any other outcome. *Conclusion:* With the exception of percentage time driving out of lane, the number of hours gaming per week does not seem to impact an individual's initial driving performance on a driving simulator. These findings may inform future driving simulation research methodology.

Introduction

Motor vehicle collisions are a public health concern in the USA and remain a leading cause of mortality. In 2022 alone, 42,795 individuals died in a motor vehicle collision and the fatality rate was 1.35 deaths per 100 million vehicle miles traveled [1]. Consequently, much effort has been put into studying motor vehicle crashes in order to understand and learn from them, as well as to prevent them in the future. In recent years, a considerable amount of research has examined driving performance using simulator-based experiments to improve road safety, identify and evaluate driving profiles, and make policy recommendations [2–4]. Driving simulations are beneficial because they allow for the standardization and testing of numerous challenging and hazardous circumstances or conditions that would not be possible during actual on-road testing (e.g., in heavy traffic and obstacles on the road). Furthermore, a number of factors contribute to this technique being a potential alternative to on-road testing for a safe assessment procedure, as well as for cost-saving, time efficiency, and reliability [5–7]. Additionally, a large amount of driving performance data can be systematically measured and collected. Thus, driving simulators are widely employed across various research disciplines and for different purposes, including the assessment of driving performance and driving behaviors.

As driving simulation research has expanded in recent years, so too, has the use of digital media. With the widespread availability of technologies such as cellphones and computers, a significant portion of the population, especially younger individuals, spend their leisure time engaging with entertainment software, such as video games. The Entertainment Software Association's 2022 study found that the top two age groups of video game players are 18–34 years (36%) and under 18 years (24%) [8]. The popularity of video games among younger populations, who are also early-stage or novice drivers, underscores the importance of understanding how video game exposure might impact driving behaviors.

However, the growing popularity of video games has triggered attention to the possibility of adverse effects on mental health and behavior, including Internet Gaming Disorder [9], increased aggression, and decreased empathy and prosocial behavior [10]. Some studies have found a higher prevalence of mental health issues particularly among adolescents with higher amounts of video game usage [11], such as anxiety and depression [12], and elevated stress levels [13]. Additionally, according to the American Psychiatric Association (APA), excessive video game use can lead to weakened social connections, decreased interest in other activities, and withdrawal symptoms, such as irritability, anxiety, or depression [14].

Despite the concerns about potential negative effects, research has demonstrated that video games can enhance cognitive tasks [15], visual functions [16,17], and general learning capacity [18], all of which may be relevant to driving – a complex activity requiring a range of cognitive and physical skills. Few studies have specifically examined the association between video gaming and various driving performance metrics, highlighting both positive and negative impacts. For example, video gaming has been shown to improve visuomotor coordination [17], which is essential for tasks like lane keeping, and responding to dynamic environments [19]. Experienced video gamers, in particular, may perform better in lane keeping tasks, demonstrating more accurate lane positioning [17,20]. Video gaming has also been associated with enhanced cognitive domains such as visual attention [21,22], hazard perception [23–25], and eye movement [23,24], all of which are vital for safe driving. One study showed that video game players, particularly older drivers, showed better overall driving performance, potentially due to improved visual attention and hazard detection skills developed through gaming [26]. However, not all effects are positive. Several studies suggested that playing video games was associated with risky driving behaviors, such as driving at higher speed [27], reckless driving [28], and risk-taking inclination while driving [29–31].

Due to the limited number of studies, it is still unknown whether the driving performance of individuals who play video games more per week differs from those who do not during driving simulations. Also, no studies have investigated the relationship between video game playing and initial driving performance in a driving simulator. To fill in the research gap, this study sought to compare specific driving performance tasks between low gaming and high gaming individuals during a brief, initial driving simulation. For this purpose, we examined driving performance tasks by employing several variables that were widely used and validated in previous driving simulation studies, such as initial collision and violation [27], turn signal performance [6], speeding [27], and driving out of lane [17,20]. This study's hypothesis was that the participants who were included in the high gaming group in this driving simulation study were less likely to experience collisions and violations, speeding, and driving out of lane, and were more likely to have good turn signal performance. The findings of this study could highlight the significant influence of video gaming on driving performance, suggesting that future driving simulation research should carefully account for video gaming experience as a critical factor that could affect outcomes.

Methods

Study design and participants

This study was a secondary analysis of data collected as part of a randomized, parallel-group, double-blind, placebo-controlled, two-arm trial clinical trial, which investigated the effects of cannabidiol oil on driving performance, cognition, psychomotor function, and subjective states among healthy, young adult volunteers. The clinical trial has been described in detail elsewhere [32,33]. The study was approved by West Virginia University's Institutional Review Board and registered on www.clinicaltrials.gov (NCT04590495). Participants of this study met the following eligibility criteria: 1) were enrolled as a student, 2) were 18–30 years of age at time of study, 3) possessed a valid drivers' license, 4) driven ≥ 1 time in the past 30 days, 5) could read English, 6) were willing to take a urine drug test and complete a test drive to ensure the absence of simulator sickness at time of enrollment, 7) were not taking any daily prescription medications (excluding birth control), 8) were not diagnosed with any serious chronic disease by a licensed healthcare provider, and 9) had an individual willing to drive them home after testing was completed. Participants were excluded if they used tobacco products, used cannabidiol in the past 7 days, used illegal drugs in the past 30 days, or were pregnant/lactating at time of study. These inclusion and exclusion criteria were intended to limit the study to healthy adults as things such as chronic conditions, prescription and non-prescription drug use, and age could confound the relationship between cannabidiol use driving performance, cognition, psychomotor function, and subjective states. A total of 40 participants were enrolled and completed the larger study.

Recruitment, screening, and enrollment

The study took place at West Virginia University, which is located in Morgantown, West Virginia, between April 2021 and January 2022. Study advertisements were sent to all students via email; additionally, electronic and paper advertisements were posted throughout campus and at popular locations in town where students frequented. Individuals who were interested in participating in the study contacted research staff. Using a standardized checklist, 96 individuals were pre-screened, and 58 were scheduled for testing. Participants were instructed to do the following prior to their testing appointment: 1) abstain from taking any medications, vitamins, or supplements for 24 hours, 2) to not consume alcohol or caffeine for 10 hours, and 3) attempt to get at least 6 hours of sleep. All visits were scheduled at the same time in the morning. At the laboratory, study personnel re-screened participants; if participants did not follow the pre-visit instructions, their appointment was rescheduled for another date. After written consent was obtained, participants provided urine samples, which were immediately analyzed for amphetamines, barbiturates, benzodiazepines, buprenorphine, cocaine, heroin, marijuana, methadone, methamphetamine, methylenedioxymethamphetamine, opiates, morphine, oxycodone, and phencyclidine. If the individual tested positive for any substance, they were ineligible to participate.

If a participant's sample tested negative for drugs, they completed a 10-minute drive on the STISIM Drive M1000 driving simulator, which was designed to simulate a range of real-world driving conditions. The simulator was equipped with one screen, steering wheel, controls, brake, and accelerator pedals. All participants were given identical instructions; they were advised to drive as they normally do in real life, obey traffic rules, and maintain control of the vehicle. This particular driving scenario took approximately 10 minutes to complete and ran through a metropolitan area, farmland, a school zone, and residential condominium scenes; this scenario is often used for pre-/post-driving rehabilitation assessments. The driving segments did require sudden braking due to pedestrian activity and other driver behaviors, turns, adaptations in speed, following navigational instructions, maneuvering, and lane maintenance. In relation to the larger study, this drive was intended to provide the participants practice time on the simulator and also served as a screen for simulator sickness [34]. If physical evidence of simulator sickness occurred (e.g., participant reported being nauseated, dizzy, disoriented, sweaty, etc.), the individual was ineligible to participate in the primary study. Simulator sickness was not observed among any participants.

Data collection and measures

After enrollment, all participants took a standardized, self-reported baseline survey to gather information on their demographics, driving behaviors, and video gaming habits. The questions used in the survey were taken from valid and reliable transportation and health surveys, including the Behavioral Risk Factor Surveillance System, National College Health Assessment, and the Traffic Safety Culture Index Survey [35–37]. The baseline survey was pilot-tested prior to use. While enrolled participants went on to perform additional tasks as part of the clinical trial protocol, this study utilized the data collected from the baseline survey and the initial 10-minute drive conducted at enrollment which was described above. Thus, these data preceded the randomization and allocation to treatment groups.

The primary independent variable was the average number of hours that the participant reported playing video games per week on any platforms (e.g., personal computer, cellphone, or gaming station). The question was worded as follows, *"On average, how many hours per week do you typically spend playing video games on a personal computer, cellphone (i.e. gaming apps), or on a gaming station (i.e. Xbox, PlayStation, etc.)?"* These data were dichotomized as ≤ 10 (e.g., low gaming group) or > 10 hours (e.g., high gaming group) per week. The decision to dichotomize the variable was made as the distribution of gaming hours was bimodal and no universal definition of high or low gaming exists in the literature. It is important to note that we did not differentiate between different types of games played (e.g., action-oriented games, strategy games, shooting, etc.), which could influence driving performance. Other covariates of interest included patients' age, sex, and average miles driven per week; these variables were considered the most important potential confounders of the relationship between gaming and driving performance.

The primary dependent variables were six driving performance metrics that were collected by the driving simulator. The first metric was the time in seconds that it took the participant to complete the driving scenario (i.e., drive time); this served as the overall time at which participants completed the driving scenario, but it does not directly measure whether or not they were exceeding the speed limit at any point during the drive. The second metric was the total percentage of time that the participant spent driving outside their travel lane; as the driving scenario did require turns but did not require lane changes/passing, this served as a measure of vehicle control. The third metric was the percentage of time that the participant spent driving > 3 miles per hour or more over the designated speed limit; this served as a direct metric for speeding. The fourth metric was the proportion of "good" turn signal usage out of the total possible turn signal maneuvers. "Good" turn signal use was when the driver signaled for a turn in advance. "Poor" turn signal performance was recorded when participants failed to use a turn signal when required, or using it too late. This value ranged from 0 to 1 with values closer to 1 indicating better performance. Turn signal performance served as a metric of driving error. The fifth metric was the time in seconds that elapsed from the beginning of the driving scenario until the drivers first collision with an object (e.g., another vehicle, pedestrian, roadside object, curb, sidewalk, etc.) in the simulation. The last metric was the time in seconds that elapsed from the beginning of the driving scenario until the participants' first driving violation. Driving violations included driving 3 miles per hour of more over the speed limit, not obeying a traffic control device (e.g., stop light and stop sign), colliding with an object, or not obeying navigational instructions. Both time to violation and collision served as direct metrics of driving error. Given that the focus was on initial driving performance, the authors felt times to violation and collision were more informative than simply providing whether a collision or violation happened. These driving performance metrics were recorded automatically by the simulator throughout the session. This standardized scenario was intended to reflect typical driving conditions while ensuring consistency across all participants.

Statistical analyses

All analyses were performed using SAS version 9.4. Demographic characteristics of the gaming groups were compared via descriptive statistics. For categorical demographic variables, characteristics were compared using Fisher's exact tests due to sample size. Mann–Whitney U tests were utilized for non-normally distributed, continuous, demographic variables. To compare drive time, percentage of time out of lane, percentage of time speeding, and turn signal usage between groups, individual analysis of covariance models were run; these models were adjusted for age, sex, and miles driven per week. This type of regression was chosen because the models contained continuous and categorical predictors along with normally distributed continuous outcomes [38]. To compare the time until first collision and time until first violation between treatment groups, both crude and adjusted Cox proportional hazards models were run to calculate hazard ratios (HRs) and 95% confidence intervals (CIs); Schoenfeld residuals were analyzed to ensure the proportional hazards assumptions were not violated [39]. The low gaming group served as the referent. Crude models contained only time until collision or violation (i.e., dependent variable) and gaming group (i.e., independent variable). Adjusted models included both variables from the crude model along with age, sex, and miles driven per week. Kaplan–Meier curves were plotted along with log-rank tests to compare survival curves of the gaming groups [40]. For all outcomes, the effect sizes between gaming groups were calculated using Cohen's d with a small sample size correction [41]. All analyses utilized two-tailed hypothesis tests with α=0.05. A *post hoc* power analysis was conducted using G*Power 3.1.9.7 for some driving outcomes [42].

Results

Demographic characteristics of the study population by gaming group are shown in Table 1. The participants' average age was 21.2 ± 2.7 years, 48% were male, and average miles driven per week was 49.5 ± 52.7 miles. Among the 40 individuals who were enrolled and completed the study, 29 were low gamers and 11 were high gamers. There were no statistically significant differences between the two groups.

The regression results for four driving performance outcomes are shown by gaming group, age, sex, and miles driven per week in Table 2. When adjusting for age, sex, and miles driven per week, the high gaming group spent a mean of 4% less time driving out of lane compared to the low gaming group (β = -4.03, SD = 1.32, $p \leq 0.05$). Additionally, all four driving performance outcomes did not show significant impacts on sex differences observed in this study. The effect sizes (Supplementary Table 1) between the two gaming

Table 1. Demographics of study participants by gaming group (N = 40)

Characteristics	Low Gaming Group (N = 29)	High Gaming Group (N = 11)	Total (N = 40)	p-value
Age in years, Mean (SD)[a]	20.8 (2.6)	22.4 (2.9)	21.2 (2.7)	0.09
Male sex, N (%)[b]	11 (37.9)	8 (72.7)	19 (47.5)	0.08
Miles driven per week, Mean (SD)[a]	44.6 (43.0)	61.8 (73.1)	49.5 (52.7)	0.67

[a]P-values calculated with Wilcoxon test comparing the low gaming with the high gaming group.
[b]P-value calculated with Fisher's exact test owing to small cell counts comparing the low gaming and the high gaming group.

Table 2. Regression results for driving performance outcomes (N = 40)

	Mean percent of "good" turn signal performance β (SD)	Mean drive time β (SD)	Mean percent time spent speeding β (SD)	Mean percent time spent out of lane β (SD)
Variables				
Intercept	0.258 (0.291)	621.607 (78.908)	−10.329 (5.281)	7.120 (4.544)
Gaming group[a]	0.028 (0.084)	20.922 (22.832)	−2.004 (1.528)	−4.034 (1.315)*
Age	0.013 (0.014)	−1.304 (3.852)	0.677 (0.258)*	0.142 (0.222)
Sex	0.011 (0.077)	−26.951 (20.867)	−0.820 (1.396)	0.382 (1.202)
Miles driven per week	−0.000 (0.001)	−0.016 (0.188)	0.002 (0.013)	−0.002 (0.011)
R square	0.040	0.065	0.189	0.227

[a]The low gaming group and females served as the referent.
*Statistical significance ≤ 0.05.

groups ranged from 0.17 to 1.15. *Post hoc* power analyses showed that power was ≥ 0.72 for most outcomes (Supplementary Table 2).

The survival curves showing time to collision and time to violation are shown in Figure 1 and 2, respectively. There were no statistically significant differences between the gaming groups. Although not statistically significant, the Cox proportional hazards model (results shown here) determined that participants who were in the high gaming group were 37% less likely to experience the first collision than those who were in the low gaming group, when controlling with age, sex, and miles driven per week (HR = 0.63, 95% CI = 0.18–2.18). Additionally, participants who were in the high gaming group were 13% less likely to experience the first violation than those who were in the low gaming group, although not statistically significant (HR = 0.87, 95% CI = 0.39–1.91).

Discussion

This study sought to compare the specific driving performance outcomes between individuals who played video games more per week (e.g., high gaming group) compared to those who played less (e.g., low gaming group) during an initial driving simulation. This study found that the high gaming group spent less time driving out of their travel lanes when compared to the low gaming group. However, no other differences in driving performance outcomes were observed between the groups which has important implications.

The findings of this study mainly coalesce with the limited extant literature. Previous driving simulation research found that young adult females and males performed similarly in their driving skill ratings which may be attributed to their inexperience [43,44]. In line with these studies, the present work also found no statistically significant differences by sex in driving performance metrics, suggesting that inexperience, rather than gender, may play a more critical role in simulation studies conducted with young adults.

A key finding in this study was that the high gaming group spent statistically significantly less time driving out of lane compared to the low gaming group, supporting a limited number of previous studies that have explored the potential benefits of action-oriented video games in enhancing lane keeping ability [17,20,45,46]. For instance, one study found that playing racing and shooting-oriented games for 5–10 hours improved lane keeping in a driving simulation among college-aged males in China [17]. Similarly, a study conducted with undergraduate students ($N = 138$) in Australia found that individuals who played action-oriented video games had better lane maintenance and less speed variability compared to non-gamers during a 40-minute driving simulation [46]. Another study conducted in the USA also found that action-oriented video gamers showed improved lane keeping ability compared to non-gamers, although this advantage was not evident during a distracted driving task [20]. Taken together, these findings suggest that video game experience, particularly with action-oriented games, could lead to improved lane keeping precision in a driving simulator. This study adds to the extant literature by showing how those playing video games may differ during initial drives in a simulator. However, more research is required to fully understand the mechanisms behind these improvements, whether they vary in shorter or longer drives, and to explore whether specific types of video games yield more pronounced benefits.

One significant distinction between this study and prior work is the absence of a statistically significant correlation between playing video games and risky driving behaviors, such as speeding, after controlling for demographic characteristics. In contrast, previous

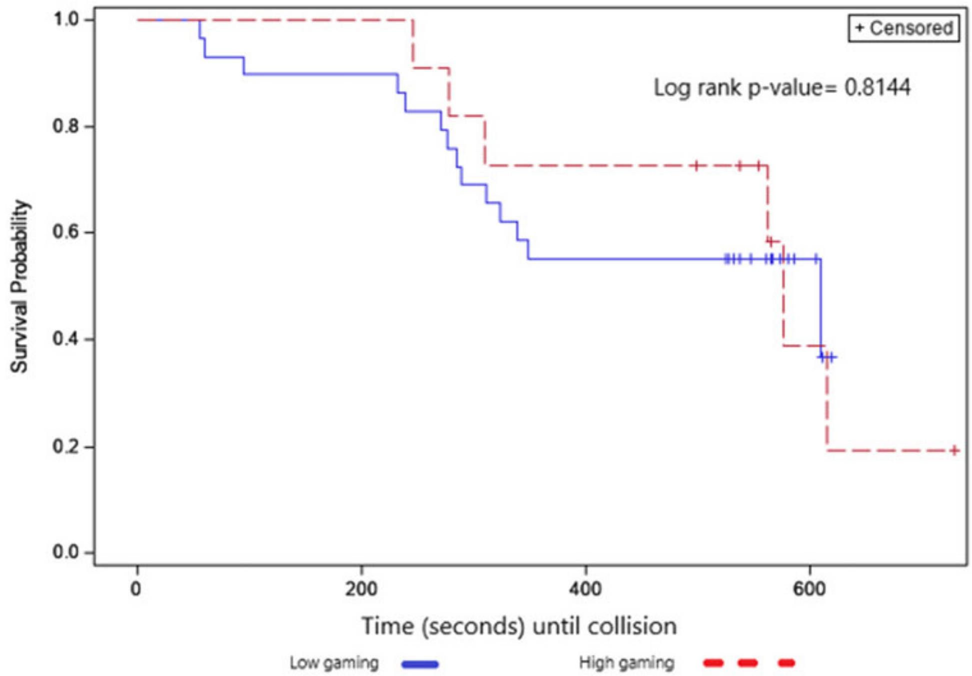

Figure 1. Time until the first collision by gaming group. Survival curves were compared using the log-rank test.

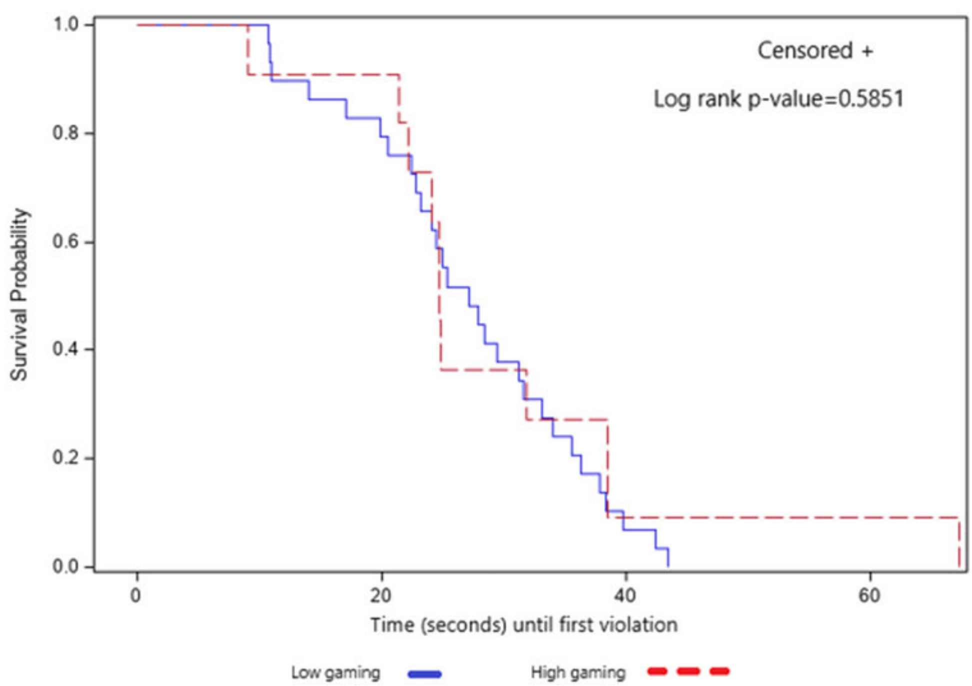

Figure 2. Time until the first violation by gaming group. Survival curves were compared using the log-rank test.

studies conducted with adolescents have found positive correlations between playing action-oriented games (e.g., racing and risk-oriented games) and risky driving behaviors like speeding [27,28]. These studies suggest that the fast-paced, risk-taking scenarios depicted in certain types of video games may contribute to the development of personality traits consistent with risk-taking and rebellious tendencies. These traits may then manifest in real-world driving behaviors. However, the lack of such a correlation in the present study may suggest that other factors, such as the type of video games played or individual personality traits, could mediate this relationship. This highlights a critical research gap – future studies should examine specific game genres and gaming behaviors to better understand their potential impact on risky driving tendencies.

Despite these findings, this study has some important implications. Due to the limited extant literature, it was unknown whether video gaming could be a potential confounder of the relationship between driving performance and other key demographic variables in driving simulation studies. Based on the

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findings of this study and the limited extant literature, individuals who play video games more frequently may perform better on some key metrics (e.g., lane keeping) but not others during initial drives on a driving simulator. This suggests that collecting data on video gaming habits, including the number of hours individuals played, could provide valuable insights in future studies. Additionally, future research should investigate driving performance outcomes over longer periods and assess more nuanced lane keeping metrics, such as the standard deviation of lateral position (SDLP). Further research is also needed to explore how different types of video games impact driving skills, as this could have significant implications for road safety and driving simulation research. Understanding the specific effects of various game genres on driving behaviors could help improve simulation methodologies and provide insights into how video games might be used as tools for enhancing certain driving skills or mitigating risky behaviors.

While this study contributes to the limited extant literature on the association between video gaming and simulated driving performance, it is not without limitation. First, while research shows that simulated driving performance is correlated with actual driving performance [47–51], there are still limitations with simulated driving research. For example, it can be challenging to compare research findings across different driving simulators due to how parameters are collected and how driving simulator performance is quantified [52]. Additionally, participants might experience side effects during simulations, such as dizziness, nausea, vomiting, and sweating [53,54]; although no participants experienced simulator sickness in this study. Second, the study population consisted of 40 young adults attending a university in West Virginia. Thus, the results of this study might not be generalizable to the general US population or older adults, who could potentially benefit from playing video games [55]. The baseline survey did not ask about the specific types of video games that the individual played (e.g., racing games) nor differentiated the hours spent playing by platform (i.e., cellphone, gaming console, computer, etc.). Previous studies found a significant association with the playing of racing games and risk-taking [29–31] and can further predict future risky driving behaviors among adolescents [56,57]. It is entirely possible that the study participants were not playing these types of video games, but this is unknown. Additionally, the classification of low- and high gaming groups was based on self-reported video gaming experience by hours; however, there is not a "gold-standard" criterion to classify individuals as high or low gaming by specific hours in the extant literature. Also, the number of hours playing video games might not be correlated with skill level necessarily. For example, it is possible that some participants met the criteria for a high gaming group, but their level of skill was low. Thus, the driving performance outcomes assessed in this study might underscore the complexity of the relationship between playing video games and driving behaviors, emphasizing the need for further comprehensive research. This study only investigated initial driving performance. It is possible that the performance of the gaming groups differed over a longer period of driving time in the simulator. Only a few driving metrics were compared. It is possible that the groups differed on other metrics that were not collected such as SDLP; SDLP was not collected during this particular scenario because there was not a long enough time nor adequate driving condition to assess it. Lastly, the study size was small. The effect sizes between groups were small for time to violation and drive time; power was lower (e.g., 0.72) for drive time specifically. Although, power was adequate (i.e., > 0.80) for most metrics. Also, the R-square was low in some of the regression models. This is likely due to the limited number of covariates included in the models; as the sample size was small, only a limited number of covariates could be included in the models.

Conclusion

This study provides novel evidence that the number of hours gaming per week does not seem to impact an individual's initial driving performance on a driving simulator among young adult drivers. However, the high gaming group showed better lane keeping ability during the driving simulation compared to low gaming group. These findings may inform future driving simulation research methodology and suggest the potential implications of assessing the correlation between playing video games and driving performance.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/cts.2024.655.

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