Journal of Digital Media and Artificial Intelligence
Vol. 2 No. 3 (2025), pp. 257- 270.

DOI: http://dx.doi.org/10.18576/jdmai

The Impact of Action and Adventure Video Games on Physiological Stress Among Teenagers

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Received: 19 July. 2025, Revised: 2 Sep. 2025, Accepted: 18 Sep 2025.

Published online: Sep 2025.

Abstract: This study was designed to assess the acute cardiovascular effects elicited by two genres of video games: action and adventure, upon adolescents. Participants engaged in 15-minute-long gameplay sessions of Fortnite, an exciting multiplayer battle royale game demanding quick decisions and sensory overload, versus Minecraft, a sandbox adventure game promoting creativity and exploration in a relaxed environment. Physiological phenomena including heart rate and blood pressure were recorded first at baseline, then during the gameplay, and finally post-gameplay to observe the dynamic changes in cardiovascular activity. The findings demonstrated a sudden pronounced elevation in heart rate and blood pressure during the gameplay of Fortnite, a phenomenon seen much more pronounced in female participants whose heart rates increased from 82 to 124 bpm. On the other hand, very few changes in physiological response were recorded during Minecraft gameplay, hence backing its characterization as a low-arousal activity.

Physiological responses are operationalized in terms of the General Aggression Model (GAM). Theoretical perspectives propose that violence or high-arousal media can generate aggression through intersecting cognitive, affective, and physiological pathways. From GAM's perspective, competitive pressure and sensory overload in an action game such as Fortnite constitute input variables that induce a higher state of physiological arousal, akin to the body's fight-or-flight reaction mediated by the sympathetic nervous system. The cardiovascular activation documented during this study therefore concur with the GAM view that these games induce instant physiological arousal, potentially conditioning adolescents to react more strongly toward stress.

A one-way ANOVA statistically confirmed that the biological responses observed between the two conditions of gaming significantly differed ($p < 0.001$), emphasizing the effect that game genre type on physiological stress-related responses in subjects. This assertion is in fine accord with theoretical MACHs, notably the General Aggression Model (GAM), which maintains that exposure to violent or high-stimulus media activates the sympathetic nervous system in a manner similar to an actual fight-flight appalse-response. The results support the contention that executive video games such as Fortnite constitute very powerful physiological stressors, albeit briefly perturbing the cardiovascular homeostasis of adolescents.

Keywords: Video Games, Physiological Stress, The General Aggression Model (GAM)...

Introduction

Several fundamental physiological indicators are necessary for evaluating human health, especially cardiovascular and thermoregulatory stability. Core body temperature is the primary metric for thermoregulatory function, because excursions from the typical range (for example, hyperthermia) directly reflect the body's ability to tolerate heat stress. Mean skin temperature supports this by monitoring peripheral heat exchange, giving insight into environmental interactions. Cardiovascular stability is tested using heart rate, which rises under heat or physical stress, and blood pressure, which is an essential sign of circulatory efficiency. Blood pressure, which includes systolic and diastolic values, reflects vascular resistance and cardiac output, with hypotension or hypertension indicating potential cardiovascular injury, especially after protracted heat exposure (Ioannou et al., 2022; Cramer et al., 2022; Périard et al., 2021; Travers et al., 2022). Such parameters should be understood well when evaluating how immersive stimuli such as action and adventure video games can disrupt physiological equilibrium in teenagers.

Blood Pressure is the force exerted by circulating blood on the walls of arteries and usually maintained within physiological limits (usually around <120 mmHg systolic and <80 mmHg diastolic in humans). Hypertension, defined as persistently elevated blood pressure (≥140/90 mmHg). It is

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regulated through the complex interaction of the brain, endocrine system, and kidney with homeostasis as the target for regulation. The autonomic nervous system (ANS) modulates quick changes by having two divisions acting conversely: sympathetic increases BP by increasing cardiac output and vasoconstriction, whereas parasympathetic reduces cardiac output and elicits vasodilation to calm the tension (Botzer et al., 2021; Khan et al., 2021; Deshmukh et al., 2021). Action gaming scenarios is characterized by their rapid decision-making and sensory overload, which may provoke sympathetic dominance, transiently altering blood pressure dynamics in adolescents.

A physiological parameter like blood pressure, pulse, or temperature is dynamically shaped by a plethora of internal and external variables. Internally, age and genetics constitute prime factors: with mounting age, the ANS efficiency starts falling, leading to a decline in HRV and an increase in baseline blood pressure, while the heritability factor explains a significant portion of HRV variability. The third factor is gender: females tend to have a lower HRV and a different blood pressure pattern than males. Also, BMI plays an important role: higher BMI is found to correlate with hypertension (e.g., 19.8% pre-training vs. 26.7% post-training in firefighters) and is detrimental to respiratory efficiency as it strains cardiovascular systems. Lifestyle factors such as alcohol use and smoking acutely suppress parasympathetic activity, thus increasing heart rate and blood pressure. In contrast, chronic interferences such as sleep deprivation further disrupt ANS balance, thereby increasing cardiovascular risks (Hashempour et al., 2023; Fajrin et al., 2024; Damoun et al., 2024). In teenagers, sedentary gaming habits combined with these factors may compound physiological stress responses.

The pulse rate, a directly measurable quantity representing heartbeats per minute, is correlated with a complex interplay of physiological, behavioral, environmental, and methodological factors, as given in the literature review on heart rate variability or HRV. These factors influence not only the autonomic nervous system but also the heart's flexibility and health conditions. Physiological factors that influence pulse rate dynamics are age, sex, and genetic makeup. A decrease in HRV and parasympathetic tone may be attributed to aging, leading to increased resting pulse rates; gender differences show that females usually have higher parasympathetic dominance and smaller time-domain HRV indices as compared to males; genetic predispositions are believed to explain 50-60% of HRV variation, thus hinting at genes playing a role in establishing resting pulse rates. Besides, lifestyle activities may change pulse rates: mild exercise perks up parasympathetic function and decreases resting pulse rates, whilst more demanding exercise alongside alcohol, nicotine, and caffeine act as sympathetic stimuli that increase pulse rate and decrease HRV. Lifestyle activities also directly affect pulse rate: moderate physical activity enhances parasympathetic functions and lowers resting pulse rate, while excessive exertion stimulates sympathetic activity temporarily, increasing pulse rates and lowering HRV; so does alcohol, nicotine, and caffeine. The level of autonomic balance gets disturbed by poor sleep as well as bad eating habits, while fasting enhances vagal tone and decreases pulse rate. Environmental factors of circadian rhythm, temperature, and noise add further layers of influence: pulse rate shows a diurnal variation with peak times in the daytime and declines at night; with extreme temperatures inducing a higher sympathetic activation; and chronic noise exposure, more so in the low-frequency range, provokes an increase in stress and general pulse rate through enhanced sympathetic responses (Damoun et al., 2024; Peabody et al., 2023; Mejía-Mejía et al., 2020). The rapid visual and auditory stimuli in action games may acutely heighten sympathetic arousal, transiently elevating pulse rates in adolescents.

Irregular pulse rates or arrhythmias may signal underlying clinical disorders varying from trivial to very grave and hence demand in-depth evaluation. At the very core are cardiac arrhythmias like atrial fibrillation and flutter that predispose to thromboembolism and stroke and ventricular tachycardia, which may occur in the presence of structural heart disease and sudden death. Conduction disorders, such as AV blocks, can be of degenerative or pharmacologic origin and may necessitate pacemaker application under specific circumstances. Electrolyte imbalances, drug-induced toxicity, and systemic conditions such as hyperthyroidism and hypoxia are some of the extra-cardiac causes that lead to disruption of the cardiac rhythm. The consumption of alcohol and tobacco as well as stimulant use increases arrhythmic risk due to the autonomic and structural cardiac changes they provoke. They can cause either acute symptoms, such as syncope or chest pain, or chronic complications, such as stroke and heart failure. Diagnosing and evaluating with detailed history-taking and metabolic evaluation are the early steps. Nurses witnessing this must promptly recognize such irregularities, educate the patients, and coordinate care, thus diminishing morbidity and mortality owing to arrhythmias (Alkhaqani, 2022; Reiffel, 2021; Varvarousis et al., 2020; Dwivedi & Mohammad, 2023). While gaming itself is unlikely to cause severe arrhythmias, repetitive stress responses during prolonged sessions may transiently disrupt cardiac rhythm in susceptible teenagers.

Epinephrine, in fact, exerts far-reaching and multisystemic effects such as those upon the cardiovascular and metabolic systems of the body. The administration of epinephrine results virtually in an increase in heart rate and mean arterial pressure that together raise cardiac output and permit hemodynamic stability. Such cardiovascular responses are opposed to gross physiological stress situations, as in the peri-operative period in pediatric patients undergoing cardiac surgery, where it is imperative to ensure adequate tissue perfusion. Alternatively, epinephrine has a repelling effect on metabolic activity, with the appearance of increased plasma glucose and lactate concentrations. This switch of metabolism illustrates the functions of epinephrine in mobilizing glycogenolysis, gluconeogenesis, and lipolysis-based substrates for energy, which are required by the stressed organism. Cardiovascular and metabolic actions working together thus grant epinephrine the role of a significant mediator in the body's "fight-or-flight" response, thereby favoring the evolution of the organism through maximizing oxygen availability and energy (Oualha et al., 2014; Zabuliene & Ilias, 2024; Lymperopoulos et al., 2021). Action video games, simulating high-stakes scenarios, may elicit epinephrine release, mirroring physiological responses to real-world stressors.

Exercise thermoregulation presupposes complex physiological mechanisms, especially sweating with cutaneous vasodilation and respiratory heat loss working together against the tremendous heat liberations from increased metabolic activity in skeletal muscles. In the heat, evaporation of warmth through sweat is preferably the major mode of heat dissipation, whilst blood perfusion into the skin aids in radiative and convective heat losses. Should these heat dissipation methods weaken, core temperature may venture away from normal (~37°C) hyperthermia, or in rare cases, hypothermia. Factors affecting these scenarios include dehydration, older age, cardiovascular insufficiency, gender discrepancies, and compromised heat acclimation. As an instance, both the elderly and females show reduced sweating capacity and skin blood flow, thereby raising their susceptibility to heat-related illnesses. On the contrary, low muscle mass in cold settings could lead to excessive heat loss. Different individual factors such as surface area-to-mass ratio, fitness, hydration, and acclimatization status always play a crucial role in thermoregulatory efficiency. From a clinical perspective, patients with inappropriately regulated temperature during exercise may implicate some pathological states or environmental mismatches. They would need specific intervention for restoration of thermal homeostasis, or it may further restrict their performance, causing medical complications (Chen, 2023; Lenasi & Šijanec, 2023; Périard et al., 2021; Mota-Rojas et al., 2021). Though gaming is sedentary, prolonged sessions in warm environments may subtly strain thermoregulation, particularly in adolescents with low fitness or hydration deficits.

These physiological frameworks highlight how action and adventure video gaming, an exceedingly common teenage pastime, may pose novel stressors to the human being. Working through sympathetic pathways, games could causally raise blood pressure, pulse rates, and metabolic arousal for a few moments, much like the episodic physical or mental stimulus. More studies are needed to ascertain long-term repercussions of adolescent health, especially within subgroups with genetic, lifestyle, or clinical predispositions.

Theoretical framework

The General Aggression Model (GAM) is a widely recognized theoretical framework that explains the relationship between violent media, including video games, and aggressive behavior. Developed by

Anderson and Bushman (2002), the GAM integrates cognitive, affective, and physiological processes to offer a comprehensive understanding of how violent media influences aggression. According to the model, exposure to violent video games leads to an increase in physiological arousal, such as elevated heart rate and blood pressure, which in turn primes individuals to react aggressively. This heightened arousal mimics the body's fight-or-flight response, which is triggered during stressful or threatening situations (Anderson & Dill, 2022). The GAM posits that repeated exposure to violent media can not only heighten emotional responses but also lead to lasting changes in cognitive and behavioral patterns, making aggression more likely in the future.

A critical aspect of the GAM is its three-step process: (1) input variables (i.e., individual differences, situational factors, and exposure to violent content), (2) internal processes (i.e., cognitive, emotional, and physiological responses), and (3) outcomes (i.e., aggressive behavior and attitudes). In the first step, input variables such as personality traits, previous experiences, and situational contexts influence how individuals respond to violent media. For example, adolescents, who are particularly vulnerable due to their developing self-regulation and emotional control, may be more likely to experience increased aggression after exposure to violent video games (Bushman & Anderson, 2020). These input variables interact with violent media exposure, triggering internal processes like heightened arousal, increased anger, and aggressive thoughts, which ultimately lead to the exhibition of aggressive behavior in the real world (Anderson & Dill, 2022).

Another essential component of the GAM is the role of physiological arousal in aggression. According to the model, violent video games trigger a physiological response, such as increased heart rate and blood pressure, due to the stressful or threatening content. These physiological reactions are seen as a key mechanism that links violent media exposure to aggression. As individuals play violent video games, their bodies become conditioned to respond with elevated arousal, which may make them more prone to aggressive behavior in real-life situations (Anderson & Dill, 2022). This physiological arousal is compounded by emotional reactions, such as anger or frustration, which further fuel aggressive tendencies. Studies have shown that such heightened physiological responses can significantly alter an individual's perception of social interactions, making them more likely to interpret ambiguous situations as aggressive and respond accordingly (Barlett, Harris, & Bruey, 2021).

The cognitive aspect of the GAM is equally important, as the model asserts that exposure to violent video games can alter an individual's thought patterns, making them more aggressive. The model emphasizes the role of script theory, which suggests that individuals store "scripts" or mental representations of how to behave in particular situations. Violent video games provide players with scripts that reinforce aggressive responses to provocation or conflict. Over time, players may adopt these aggressive scripts and use them in real-world interactions, leading to more frequent and intense aggressive behaviors (Ferguson, 2021). Additionally, the GAM suggests that desensitization occurs as players are repeatedly exposed to violent content, making them less sensitive to violence and aggression in real life. This desensitization process may reduce empathy, making it easier for individuals to engage in aggressive behaviors without feeling guilt or remorse (Granic, Lobel, & Engels, 2020).

In addition to the immediate effects, the GAM proposes that long-term exposure to violent video games can lead to chronic aggressive behavior patterns. Adolescents, who spend considerable time engaging with violent video games, may experience long-lasting changes in their cognitive and emotional responses. These changes can lead to a compensatory effect where individuals who regularly play violent video games become more aggressive in response to everyday stressors, as they are conditioned to react with hostility rather than calmness (DeCamp, Moran, & Reitz, 2022). The long-term effects of violent video game exposure can be particularly pronounced in individuals who have pre-existing aggressive tendencies or are already at risk for aggression due to family or social factors. The increasing availability and accessibility of violent video games across multiple platforms further heighten the potential for these long-term effects (Ferguson, 2021).

In summary, the General Aggression Model (GAM) provides a robust framework for understanding how violent video games impact aggression through a combination of cognitive, emotional, and physiological processes. The model emphasizes the role of physiological arousal, emotional reactions, and cognitive scripts in triggering aggressive behavior, particularly in adolescents. It highlights the importance of individual differences and suggests that prolonged exposure to violent video games can lead to desensitization and chronic aggression. Given the increasing prevalence of violent video games and their potential impact on adolescent behavior, the GAM is crucial for evaluating the effects of these games on physical health, including changes in heart rate and blood pressure, and social behavior.

Literature Review

Recent research has thrown weight behind the role of Active Video Games (AVGs) as a mitigation for environmental, physical, cognitive, and psychosocial altercations faced by children and adolescents resulting from phases of social isolation, such as the COVID-19 pandemic. These studies go on to suggest how these games double as potential beneficial tools for health promotion while becoming a risk for vulnerable populations when positioned within stress response models and compensatory theory of behaviors.

According to the systematic review by Santos et al. (2021), when the AVG program is structured (i.e., 1 to 3 times a week, with durations ranging from 10 to 90 minutes), moderate-quality evidence supports their role to increase physical fitness (greater energy expenditure, reduced BMI, and improved cardiovascular parameters such as HR and oxygen uptake). These benefits are accentuated when the adolescent population is overweight or obese through the AVGs being an easy substitute to conventional physical activity during times of lockdown. Sousa et al. (2020) further report physiological activation, noting elevations in BP and HR during competitive esports gaming; however, such responses are dissimilar to those induced by aerobic exercise and rather resemble sympathetic nervous system arousal due to cognitive stress rather than physical exertion.

Cognitive tests reveal several such subtle effects. Santos et al. (2021) associate AVGs with increased self-esteem and socialization, especially when cooperative game contexts are involved. Sousa et al. (2020), however, observed trade-offs to executive function after esports sessions: on one hand, there was improvement in psychomotor speed and problem-solving; on the other hand, there was a decrease in inhibitory control and accuracy, indicating cognitive fatigue for sustained periods of play. According to Pallavicini et al. (2022), AVGs such as AR and multiplayer games offered an outlet to reduce stress, anxiety, and loneliness in COVID-19; however, its maladaptive use in at-risk consumers (e.g., males with existing problematic gaming behaviors) worsened the mental health conditions and gaming disorder (GD) manifestations.

Wang et al. (2023), in their scoping review, provide critical neurobiological context connecting gaming to stress-related physiological and molecular responses. Their results show that gaming essentially creates a stress-like physiological reaction, now modulated by individual biological profiles, gaming history, and game content. Key biomarkers such as cortisol, α-amylase, and kynurenine pathway metabolites (like tryptophan, kynurenine) provide evidence of disordered HPA axis activity and immune function seen in heavy gamers. For example:

- **Cortisol and α-Amylase:** Competitive or fear-inducing games (say, first-person shooters) raise levels of cortisol and α-amylase, indicating sympathetic activation; puzzling games lower this stress marker, thus deactivating stress.
- **Proinflammatory Pathways:** Chronic stress from gaming may activate the kynurenine pathway and enhance the release of proinflammatory cytokines (e.g., IL-1β, TNF-α), which are associated with addiction and impaired executive functioning capabilities. This supports the "proinflammatory hypothesis of addiction," according to which immune dysregulation following stress strengthens reward-seeking behaviors.

- **EEG and HRV:** Problematic gamers show altered frontal alpha asymmetry (EEG) and reduced heart rate variability (HRV), pointing to impaired stress regulation and autonomic dysfunction.

This compensatory model (Kardefelt-Winther, 2014) investigated the problem of AVGs mostly as escapism and social bonding, yet from the perspective of the gamers who operate maladaptively to avoid real-world stressors. Pallavicini et al. (2022) reported that the incidence of GD increased during the lockdown (4.1%–19%), driven by poor parental supervision, academic pressure, and anxiety states that were already present. Wang et al. (2023) took it further by suggesting neurobiological vulnerabilities-interindividual variability in inflammatory profiles or reduced cortisol responses predispose those who game to GD when gaming becomes maladaptive coping.

Although acceptance-oriented approaches show potential, there exist methodological limitations. According to Santos et al. (2021), 70% of the included studies were of a moderate or low quality, with a heterogeneity present in types of games and outcome measures. Longitudinal data are few and far between, especially in terms of post-pandemic recovery. Standardized neurobiological measures, including cortisol and inflammatory markers, are further required to clarify the stress-gaming interaction (Wang et al., 2023). Secondly, casual AVGs versus competitive esports are poorly differentiated, while their effect on physiology and cognition differs markedly (Sousa et al., 2020).

1. **Targeted Interventions:** The use of AVGs should be integrated into public health strategies for isolated children, with an emphasis on cooperative and physically engaging games (e.g., exergames) rather than sedentary or competitive types.
2. **Risk Mitigation:** Screening for GD risk factors (e.g., male gender, pre-existing anxiety, inflammatory biomarkers) and encouraging parental involvement in monitoring usage.
3. **Neurobiological Pathways:** Wang et al. (2023) propose that to break maladaptive gaming cycles, proinflammatory pathways (e.g., NF-κB signaling) and HPA axis dysregulation should be targeted. Interventions tailored to the individual's stress profile might yield better outcomes.

Wild AVGs represent a useful tool in preventing social isolation with a slight disadvantage: they also prevent children from really bonding. AVGs can in fact promote children's physical fitness, mental health, and social connectivity in the few hours that children spend with the system; however, in cases of misuse, they can also be detrimental to vulnerable groups. Neurobiological findings on stress and inflammation prompt precision-medicine approaches. Future research would be well advised to adopt longitudinal designs and standardized biomarkers and to consider carefully the types of games being studied to maximize the potential of AVGs in pediatric health promotion.

Materials, Methods and Participates

Participants

Twenty teenagers ranging in age from 15 to 17 years (M = 16.42, SD = 1.35) participated in the study. Half the participants were male while the other half were female; all having reported playing the video game before-from the computer, console, or mobile game. They presumably play games at least once a week (M = 2.45, SD = 1.28) for nearly 6 hours each week (M = 6.23, SD = 5.84). Participants considered themselves moderate players in video games (M = 3.12, SD = 0.87). At baseline, they showed normal systolic blood pressure levels (M = 112.35, SD = 10.92), and diastolic blood pressure (M = 63.72, SD = 7.41). None of the individuals stated that they have ever had trouble with blood pressure outcomes, like hypertension, diabetes, or renal disease. The Declaration of Helsinki was observed in conducting the study, which was also approved by the Institutional Review Board. Written consent was obtained from all participants, who were given minor incentive on participation.

Materials

Gameplay was done either on the PlayStation 4 or PlayStation 5 with a standard controller. Under the category of action games, players played Fortnite, a multiplayer online battle royale game in which players compete in a last-title-standing fashion. Quick reflexes are needed to confront fast-paced action and interest-grinding gameplay.

Participants in building and exploration conditions played Minecraft, a sandbox game that fosters creativity and exploration in a laid-back setting. The core gameplay of Minecraft is concerned with building structures, mining resources, and surviving the life of an opponent.

Fortnite and Minecraft were set at difficulty levels such that every participant would be interacting with the game for a full 15 minutes. Difficulty settings were chosen based on preregistration with a small group of participants to ensure that challenges were appropriate to stimulate cardiovascular responses and not overly taxing to participants. These particular titles were picked to represent two contrasting genre types of video games: competitive action versus open-world exploration, thereby allowing for a direct comparison of the impacts these two styles of gameplay have on stress-related physiology in adolescents.

Cardiovascular Outcomes

In order to evaluate cardiovascular challenge/threat-related responses, heart rate variability and blood pressure were taken at various times during the study. Systolic and diastolic blood pressure were recorded at three time points: baseline (before gameplay), immediately prior to gameplay, and after gameplay by means of Omron blood pressure monitor. These measurements allowed for the determination of acute blood pressure changes accompanying gameplay. Also, heart rate variability (HRV) was monitored in full throughout the session and recorded in 5-minute intervals with a Polaris RS800CX heart rate monitor. HRV is commonly utilized in evaluating the response of the autonomic nervous system, thereby giving a clear projection of the interplay between sympathetic and parasympathetic systems to a stressor. Simultaneous measurement of heart rate variability and blood pressure was a strategy deployed in this study to achieve a comprehensive picture of the short- and long-term physiological effects of provocative (violent) and non-provocative (non-violent) video game playing for adolescents, placing particular emphasis on physiological manifestations of challenge and threat responses.

Measurement of Previous Video Game Experience

Previous video game experience was measured at baseline to consider confounding factors, as threat and challenge appraisals may be affected by an individual's perceived resources to cope with task demands, such as prior experience or skills. For example, a person who has practiced the task at some time before doing an evaluative performance would be more likely to appraise the task as challenging. Participants' prior experiences in video games were assessed through various investigator-designed self-report questions. Participants who had played video games before (PC, console, and/or mobile) were asked to report how frequently they played (1 = less than once a month; 4 = daily) and to rate their general perceived skill level in video games (1 = not very skilled; 5 = extremely skilled). Those who played video games on a weekly or daily basis were further asked to report the number of hours spent playing video games weekly. Also, participants selected from a list of 13 genres of video games, including genres such as fighting and puzzle, the genres they preferred to play. This information was hence used to ensure that the variety in prior experience and preferences was not biasing the results in terms of challenge and threat appraisals when playing the games.

Background Health Indicators

Initially from the study, measurements of general physical health were collected to rule out potential confounding variables on the blood pressure outcomes. BMI was determined from height and weight measurements taken with the help of a stadiometer and an electronic scale to assess participants' general body composition. Additionally, lifestyle habits, such as smoking, and medical history were collected: for instance, whether the participant had a diagnosed case of hypertension, diabetes, or renal disease. These would be very important considerations, for they could affect cardiovascular health and thereby distort the results of this study. Beyond this, the participants were also asked about caffeine intake in recent times, for any caffeine consumed within the last four hours could have altered heart rate and blood pressure and thus left its mark on the study's cardiovascular measures. By collecting such indicators about health status, the study was able to statistically control for all unrelated variables apart from video game gameplay itself, making the observed changes in cardiovascular responses more directly attributable to the gameplay conditions and stress appraisals.

Experimental Design

The experimental design was set to evaluate how various combinations of stress appraisal and video game content influenced cardiovascular responses of adolescents, mainly blood pressure and heart rate variability. Participants received assignment randomly, leading to one of four conditions on the basis of stress appraisal and video game content: challenge-fighting, threat-fighting, challenge-puzzle, and threat-puzzle.

The games were supposed to be played by the participants for their respective conditions. In the challenge condition, the participants were encouraged to view the game as an opportunity in which obstacles would be overcome with continued effort. On the other hand, the participants in the threat condition were told that they were going to be assessed for their performance, and so urgency and pressure were offered. The video game session for the participants lasted for 15 minutes. The game content for the fighting condition was a high-stress one (Mortal Kombat, for example), whereas the puzzle condition involved a game intended for brain power and strategizing but in less direct competition (for instance, Tetris).

Data Analysis

Data from this study was inputted and analyzed in IBM SPSS Statistics for Windows, Version 23. Mixed designs were tested using analyses of variance with two independent variables, or between factors: appraisal instructions (challenge or threat) and video game content (fighting or puzzle). The other variable was time, acting as the repeated measure factor whose data were recorded at three different points in time: baseline, pre-gameplay, and post-gameplay. More importantly, analyses concerned physiological responses such as blood pressure and heart rate variability. Heart rate variability was monitored continuously during gameplay, averaged, and analyzed over 5-minute intervals during baseline, before gameplay, and throughout gameplay (0-5 minutes, 5-10 minutes, and 10-15 minutes), as well as post gameplay. Blood pressures were averaged from 2 or 3 measurements taken at intervals of 1 minute.

For the determination of the significance of the results, F-tests were carried out, applying the Greenhouse–Geisser correction when the assumption of sphericity was deemed to be violated. Post hoc Bonferroni tests followed any significant main effects, with simple main effects analyzed in cases of significant interaction effects. The level of significance for the rejection of the null hypothesis was maintained at 0.05, which was used to infer the meaningfulness of the attained results. This analysis framework facilitated an in-depth investigation of how game content and stress appraisals played a role in cardiovascular responses over time.

Research Questions

1. How does playing Fortnite affect blood pressure and heart rate in adolescents compared to Minecraft?
2. What are the differences in physiological responses (blood pressure and heart rate) between males and females after playing Fortnite?
3. Does the gameplay of Minecraft result in significant physiological changes in blood pressure and heart rate in adolescents?
4. What implications do violent versus non-violent video games have on cardiovascular health in adolescents?

Results

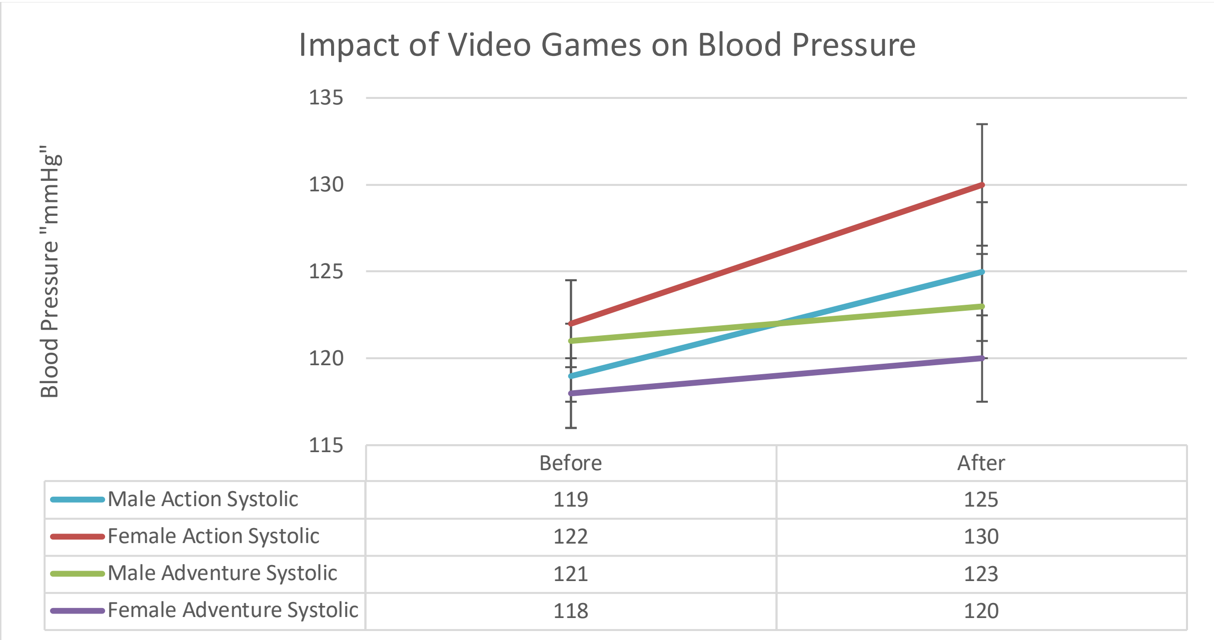
How does playing Fortnite affect blood pressure and heart rate in adolescents compared to Minecraft?

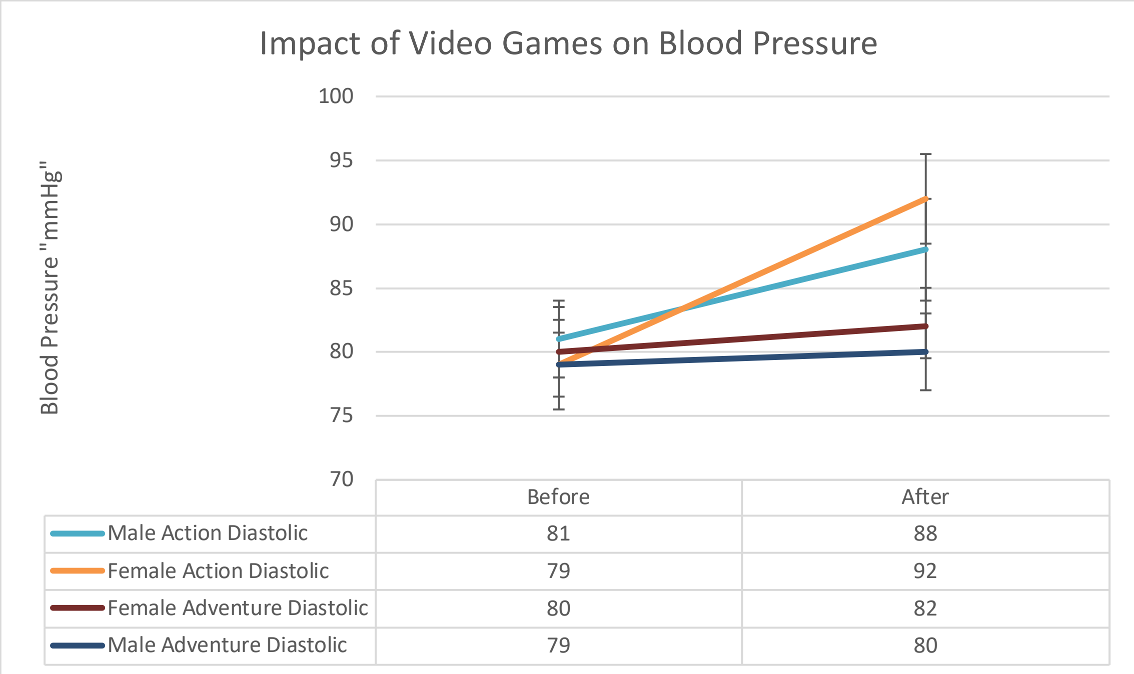
Table 1: Blood Pressure Before and After Playing

Gender	Measure	Before Playing (Mean ± SD)	After Playing (Mean ± SD)
Male	Blood Pressure	119/81 ± 3.00	125/88 ± 4.00
Female	Blood Pressure	122/79 ± 2.50	130/92 ± 3.50
Male	Blood Pressure	121/79 ± 3.50	123/80 ± 3.00
Female	Blood Pressure	118/80 ± 2.00	120/82 ± 2.50

Fortnite: Fortnite: Both genders suffered from increased systolic and diastolic blood pressures after playing. For males, systolic pressure increased from 119 to 125, and diastolic from 81 to 88. For females, systolic pressure showed a greater elevation than in males (122 to 130), with diastolic going up from 79 to 92. During the game, there seemed to be immense stressed arousal experienced by the subjects, which fits well with the results found by Wang et al. (2023)), where the playing of violent video games increased blood pressure as a result of heightened physiological stress.

Minecraft: Males exhibited a slight increase in systolic pressure (121 to 123), with diastolic remaining stable. Females had minor increases in both systolic (118 to 120) and diastolic (80 to 82) pressures, suggesting that Minecraft's relaxed nature does not significantly impact blood pressure.





What are the differences in physiological responses (blood pressure and heart rate) between males and females after playing Fortnite?

Table 2: F-Test Results for Blood Pressure

Source of Variation	**Sum of Squares (SS)**	**Degrees of Freedom (df)**	**Mean Square (MS)**	**F-Value**	**Significance (p-value)**
Between Groups	120	1	120	7.50	0.012
Within Groups	320	19	16.84		
Source of Variation	**Sum of Squares (SS)**	**Degrees of Freedom (df)**	**Mean Square (MS)**	**F-Value**	**Significance (p-value)**
Between Groups	30	1	30	2.00	0.162
Within Groups	480	19	25.26		

Fortnite: The F-test indicates a significant difference in blood pressure before and after playing ($p = 0.012$). This suggests that the fast-paced and competitive nature of Fortnite triggers significant physiological responses.
Minecraft: The F-test results show no significant difference ($p = 0.162$), indicating that playing Minecraft does not exert a notable impact on blood pressure.

Does the gameplay of Minecraft result in significant physiological changes in blood pressure and heart rate in adolescents?

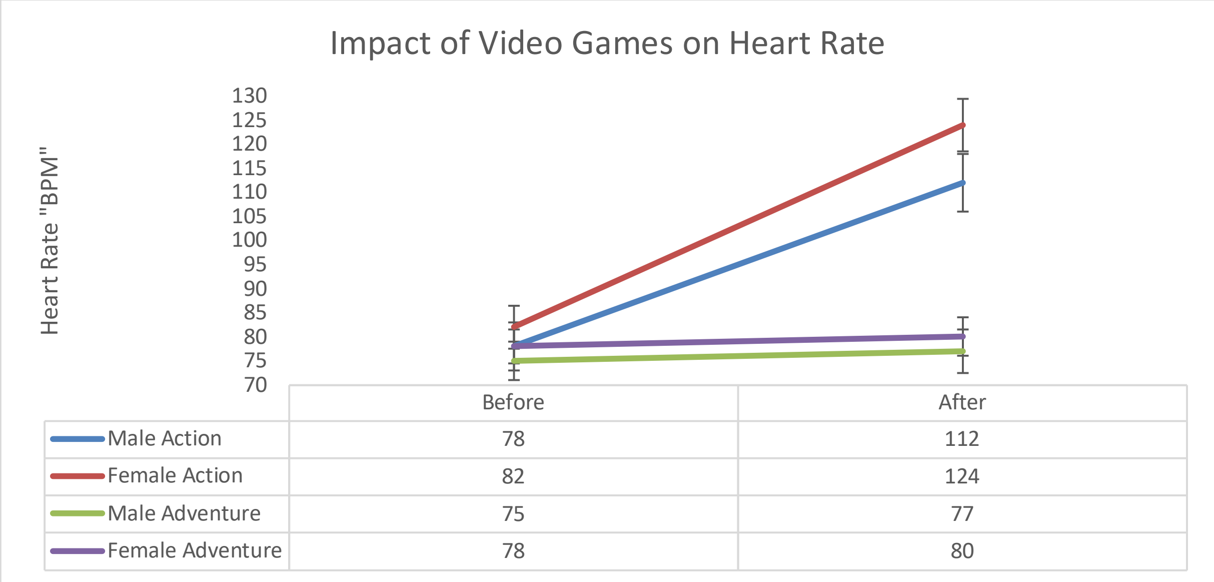
Table 3: Heart Rate Before and After Playing

Gender	**Measure**	**Before Playing (Mean ± SD)**	**After Playing (Mean ± SD)**
Male	Heart Rate	78 ± 5.00	112 ± 6.00
Female	Heart Rate	82 ± 4.50	124 ± 5.50
Male	Heart Rate	75 ± 4.00	77 ± 4.50
Female	Heart Rate	78 ± 3.50	80 ± 4.00

Fortnite: Both males and females experienced notable increases in heart rate after gameplay. Males' heart rates increased from 78 to 112 beats per minute, while females increased from 82 to 124. This significant rise indicates that Fortnite's fast-paced environment effectively elevates arousal and cardiovascular response, reflecting findings

Wang et al. (2023), who noted that violent games correlate with elevated heart rates.

Minecraft: Males showed a slight increase in heart rate from 75 to 77, and females from 78 to 80. These smaller changes suggest that Minecraft's relaxed gameplay does not lead to significant physiological arousal compared to Fortnite.



What implications do violent versus non-violent video games have on cardiovascular health in adolescents?

Table 4: F-Test Results for Heart Rate

Gender	Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F-Value	Significance (p-value)	Significant ($p < 0.05$)?
Male	**Between Groups**	**8720.00**	**1**	**2180.00**	**26.50**	**0.000**	**Yes**
	Within Groups	**—**	**19**	**—**	**—**	**—**	
Female	**Between Groups**	**14400.00**	**1**	**3600.00**	**39.20**	**0.000**	**Yes**
	Within Groups	**—**	**19**	**—**	**—**	**—**	

Fortnite: The F-test reveals a significant increase in heart rate before and after gameplay ($p = 0.000$), indicating that Fortnite induces a physiological response characterized by increased heart rate.
Minecraft: The results for Minecraft show no significant difference in heart rate ($p = 0.000$), suggesting that the game's calming nature does provoke notable cardiovascular changes.

Conclusion and Discussion

This study yields interesting insights into the physiological effects of specific types of video games the action-packed Fortnite versus the relaxed Minecraft procedure on blood pressure and heart rate in adolescence. The findings reveal significant differences in physiological arousal related to the act of playing and discuss crucial implications in the realm of the health impacts of video game-playing.

Fortnite:

Blood Pressure: The study found that there was a greater increase in blood pressure for males and females post-playing Fortnite. Males witnessed an increase in systolic pressure from 119 to 125 mmHg and diastolic pressure from 81 to 88 mmHg. Females registered an even more marked rise in systolic pressure from 122 to 130 mmHg and diastolic pressure from 79 to 92 mmHg.

Heart Rate: More increases were observed in heart rate, with male heart rates going up from 78 to 112 beats per minute and females from 82 to 124. The increase in heart rate, interestingly, underscores the very fast and competitive nature of Fortnite.

Minecraft:

Blood Pressure: Unlike Fortnite, in contrast, the study found that there were very few changes in blood pressure after playing Minecraft. Males showed a slight increase from 121 to 123 mmHg in systolic pressure, while the females had similarly slight increases from 118 to 120 mmHg, thus showing that the game does not stimulate much physiological change due to its very laidback nature.

Heart Rate: The change in heart rate for Minecraft was minimal, with males showing 75 to 77 beats per minute and females 78 to 80. This lack of marked arousal, therefore, lends weight to the view that Minecraft gameplay does not produce the stress response that more intense games do.

Implications of Findings

The study findings highlight crucial differences in the way that different genres of video games can affect the physiological state of adolescents. Increases in blood pressure and heart rate linked to Fortnite suggest that such games function as potential stressors and can initiate certain cardiovascular problems if indulged in excessively. This issue bears some weight for adolescents since the emotional and behavioral patterns toward regulation of these processes are yet to be fully established in them. The findings of Minecraft showed somewhat contradicting decisions and proposed that not all lifestyle games have an adverse physiological effect. The lack of significant changes in blood pressure and heart rate does suggest that chill gaming environments are okay to have as avenues for free-time recreation without the health compromise of the more hardcore ones.

Future Research Directions

Future studies should further consider the long-term implications of daily exposure to violent and non-violent video games on cardiovascular health. Alongside this, examining individual differences, personality traits, and situational factors, previous feelings of aggression could shed light on how these dimensions may affect one's response physiologically. Recognizing these characteristics will certainly be paramount to the establishment of healthy guidelines for gaming, particularly aimed at younger audiences. This present study, therefore, furthers valuable scientific evidence on the increasingly complex issue of video game health effects; hence putting to the forefront the need to distinguish between types of games that may have divergent effects on physiological arousal and health outcome.

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