

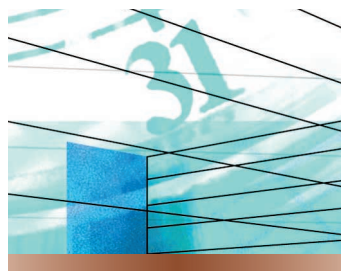
Physical Fitness in Virtual Worlds

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The percentage of overweight adolescents in the US has more than doubled in the past 20 years (Centers for Disease Control and Prevention, *Physical Activity and Good Nutrition: Essential Elements to Prevent Chronic Diseases and Obesity 2004*, US Department of Health and Human Services). Health risks associated with obesity—heart disease, high blood pressure, diabetes, and arthritic disabilities—can be reduced by adding as little as 30 minutes of physical activity to a person's daily routine. Yet one-third of American adolescents and 50 percent of adults fail to meet this minimum requirement, prompting policy makers to declare an obesity epidemic in the US.

Academic studies and news reports have suggested that the increasing number of obese youth derive at least partially from television viewing and video game use. In particular, the *couch potato hypothesis* suggests that watching television and playing video games consume time that could be spent engaging in physical activities (E.A. Vandewater, M. Shim, and A.G. Caplovitz, "Linking Obesity and Activity Level with Children's Television and Video Game Use," *J. Adolescence*, vol. 27, no. 1, 2004, pp. 71-85).

This hypothesis assumes that video gamers pursue their hobby by pressing buttons and moving joysticks while occupying comfortable chairs placed in front of large video screens. An accurate stereotype until recently, this form of gaming is being supplanted by a new generation of games and controllers that entice players to become more



By requiring rigorous physical activity, some new video games make gamers healthier.

physically active. Low-cost cameras and advanced video processing algorithms let video games be controlled by bodily movements, while touch-sensitive floor sensors let players dance in virtual spaces. Stories of people using these movement-based interfaces to lose weight have appeared on Internet sites (www.getupmove.com) and in the popular press.

MY BODY AS LABORATORY

Stephen Yang, a PhD student in Penn State University's kinesiology department, believes that video games can be used to increase physical activity and improve personal health. His research for the Gaming Activities for More Exercise (GAME) project has focused on the heart-rate intensity effects high school students experience when playing movement-based games (S. Yang and G. Graham, "Project GAME—Gaming Activities for More Exercise," *Research Quarterly for Exercise and Sport*, vol. 76, no. 1, supplement, p. A-96).

Yang found that even though these kids expend a great deal of energy, they reported that they felt great and could continue playing when their sessions ended. Similarly, other studies of

teenagers who play dancing games that employ floor sensors report energy expenditures and heart rate intensities comparable to those experienced when playing tennis and medium-intensity aerobic dancing (B. Tan et al., "Aerobic Demands of the Dance Simulation Game," *Int'l J. Sports Medicine*, vol. 23, no. 2, 2002, pp. 125-129).

Yang's preliminary results inspired me to see if I could increase my fitness

while having a bit of fun. I played three different movement-based video games every day for three months to see how doing so would affect my health.

Dance Dance Revolution

Konami released *Dance Dance Revolution* in 1998, and it rapidly became a cult phenomenon as players embraced the physically immersive dance experience. Game play takes place around a set of arrows that scroll from the bottom to the top of the screen. As the arrows hit the action bar, players use their feet to step on the corresponding arrows on the game's floor sensors and dance pads.

Players score points by timing their footsteps to the music's beat as it plays in the background. Slow songs make this task fairly easy, but faster tunes require more movement, coordination, and energy expenditure. A variety of dance pads can be purchased for major game consoles and personal computers.

EyeToy

Robust computer-vision algorithms and affordable cameras give players new ways to control virtual gaming experiences. One popular gaming camera, Sony's EyeToy, plugs into a

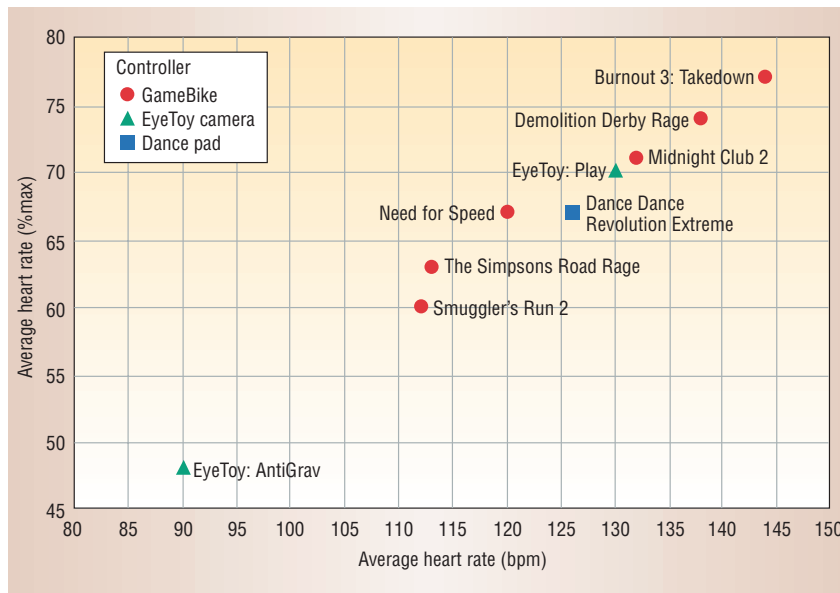


Figure 1. Heart-rate data for video games and the controllers used to play them, by average heart rate in beats per minute versus average percentage of maximum heart rate.

Playstation 2 console’s USB port and lets players control games with upper-body gestures. In most cases, players see a mirror image of themselves on the screen as they interact with virtual characters and backgrounds.

The first software for the camera, *EyeToy: Play*, consisted of several minigames based on themes such as karate, boxing, and dancing. Newer games such as *EyeToy: AntiGrav* track bodily gestures to control onscreen avatars. All the games require upper-body movements to interact with virtual worlds and contribute to increased physical activity.

GameBike

Cateye’s GameBike stationary bicycle has rotation sensors connected to the handlebar and pedals. These sensors let players control games by pedaling and steering.

GameBike is ideal for playing racing games because the sensors record speed and changes in direction. The bicycle comes in two versions: a stationary bike, which I use in my exercise sessions, and a less expensive platform that rests beneath the rear wheel of an ordinary bicycle.

HEALTH MEASURES

I recorded my weight and blood sugar levels before, during, and after the three months of game play. I had hoped to lose weight since I would spend 30 minutes a day waving my arms, dancing, and pedaling a bicycle.

As a type 2 diabetic, I also recorded long-term measures of average blood sugar—glycosylated hemoglobin or HbA1c tests—before and after the three-month period. Exercise plays a role in blood sugar control, and keeping HbA1c levels close to 7 percent increases the chances of delaying or avoiding severe health issues related to diabetes (The Diabetes Control and Complications Trial Research Group, “The Effect of Intensive Treatment of Diabetes on the Development and Progression of Long-Term Complications in Insulin-Dependent Diabetes Mellitus,” *New England J. Medicine*, vol. 329, no. 14, 1993, pp. 977-986). I also wore a Nike Triax Elite heart monitor during each game session because heart rate provides a convenient measure of exercise intensity.

Figure 1 confirms Yang’s observations of increased heart rate. Moving my body to the frenetic musical

rhythms in *Dance Dance Revolution* required a major effort. The two EyeToy games involve strenuous upper body movement, but *EyeToy: Antigrav* resulted in less heart exertion than the *EyeToy: Play* games. In the former, players use their bodies to steer a virtual character through a race course, which often involves quite subtle physical movements. *The EyeToy: Play* games might lead to higher heart rates because they require more extreme body movements.

The heart-rate variations for different games played on the GameBike surprised me. Some racing games increased my average heart rate more than others. For example, I averaged 144 beats per minute playing *Burnout 3: Takedown* versus 122 bpm on *Smuggler’s Run 2*. These variations could stem from the physics models built into the games: Virtual vehicles with rapid acceleration require less effort to pedal up to speed. But I suspect that heart rate is proportional to engagement. Increased energy expenditures while exercising have been linked to motivation (B.J. Noble, *Physiology of Exercise and Sport*, Times Mirror/Mosby College Publishing, 1986), and I certainly pedaled harder and faster when playing games that gave me the most pleasure.

I lost 8.6 lbs. after three months of playing these games. I also lowered my HbA1c level from 12.2 to 8.9 percent. This is still above the advised range but an improvement nonetheless. I might have seen more change had I altered my eating habits, but the game playing alone was enough to improve my health.

DESIGNING EXERCISE GAMES

New challenges for video game designers will emerge as they try to create motivating, virtual experiences that also increase activity. I am not a game designer, but I learned some things during my exercise experiences that might be useful for maximizing engagement and physical fitness. My research group is experimenting with the fol-

lowing ideas by building our own games to test in future studies.

Warm-up and cool-down activities

Warm-up routines help gradually prepare muscles and the cardiovascular system before exercise while cool-down routines decrease a workout's intensity to a resting condition afterward. Sports physicians recommend these activities to prevent injury and promote metabolic efficiency.

These same warm-up and cool-down activities could be incorporated into fitness games in engaging ways. For example, I used one of the *EyeToy: Play* games, *Wishi Washi*, for light intensity stretching before and after playing the more strenuous games. Most games lack ways to warm and cool the body, but it would be fairly simple for designers to integrate such activities into their virtual experiences.

Load times and target zones

Larger games take a long time to load into the console's memory. Waiting between games can interfere with a player's goal of staying within a target heart-rate zone. Figure 2 shows six races in *Burnout 3* and the decreases in heart rate between each race, a pause of about 30 seconds. I sought to stay above 130 bpm, but the long interval between each race let my heart rate drop below the target zone.

My most consistent heart rates came when playing games with long durations or that allowed me to adjust the length of play. Permitting players to extend game time before the console reloads increases their chances of staying within target heart-rate zones.

Integrating physiological measures

Some games such as *Dance Dance Revolution Extreme* let players input their height and weight into a profile and use this data to calculate the average calories burned during play. Additional physiological measures could be read from external sensors and displayed within exercise games.

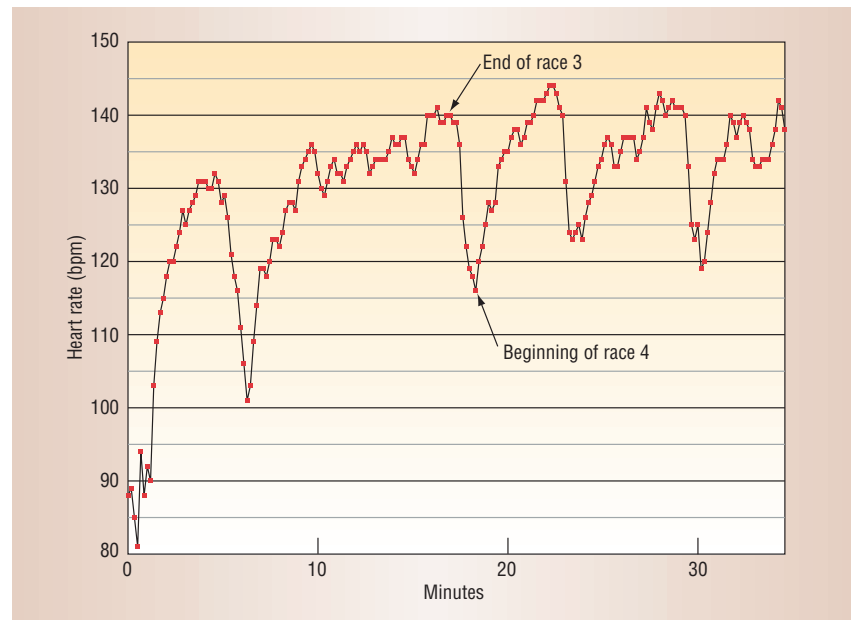


Figure 2. Heart rate over time during six races in *Burnout 3*. The heart rate moves below targeted zones during the prolonged load times between races.

For example, data from heart monitors could be shown onscreen to help players monitor their current fitness levels.

Dynamic game play adjustment

Games could be designed to proactively keep players within their target heart-rate zones. Game play could be altered in response to sensor inputs from, for example, heart monitors, pedometers, and fitness profiles the players provide. A game could then adjust its pace to keep a player's heart rate within a designated target range.

I have tried many exercise videotapes and gadgets over the years, all of which have landed in the trash or been auctioned off on the Internet. Multimodal controllers amplified the immersive experience of playing video games and helped me continue exercising for three months and beyond. Moving my body to combat virtual ninjas and dance to techno music appears strange to neighbors peering through my window, but it's a lot of fun. It also feels great to pedal and sweat like crazy when racing the computer and online opponents on my GameBike.

Meta-analyses of the literature on media use and obesity suggest that video games are unlikely to be the only cause of sedentary behaviors that lead to health complications (S.J. Marshall et al., "Relationships Between Media Use, Body Fatness and Physical Activity in Children and Youth: A Meta-Analysis," *Int'l J. Obesity*, vol. 28, no. 10, 2004, pp. 1238-1246). In light of this, the couch potato hypothesis must be reexamined now that the boundaries between physical and virtual worlds are disappearing.

My experiences playing movement-based games have already helped me lose weight and control my blood sugar, suggesting that those of us who love video games can have our virtual cake and burn it too. ■

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