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Research Article

Exergaming Intervention in Sedentary Middle-Aged Adults Reduces Cortisol Production and Psychological Stress

Daniel M Rosney*

Assistant Professor, Department of Kinesiology, Temple University, Philadelphia, Pennsylvania, USA

***Corresponding Author**: Daniel M Rosney, Assistant Professor, Department of Kinesiology, Temple University, Philadelphia, Pennsylvania, USA.

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Abstract

Background: Interactive video game technology has been extensively utilized in rehabilitative settings. However, few studies have explored the potential benefits of interactive video games as an exercise instrument to relieve stress in middle-aged adults who do not have a gym membership or who cannot otherwise regularly attend their local fitness center. Features of interactive "exergaming" (modeling proper exercise biomechanics, increasing self-monitoring of behavior, encouraging participants to set health-related goals, and rewarding regular use) may help promote physical activity and consequently reduce both physiological and psychological stress, as well as improve exercise self-efficacy.

Purpose: To compare salivary and hair cortisol production, and psychological stress and self-efficacy questionnaires, in sedentary adults before and after exergaming (n = 12, 56 ± 4 yrs, 162.1 ± 10.9 cm, 79.2 ± 19.1 kg, 39.6 ± 7.7% fat mass).

Methods: Subjects initially provided saliva and hair samples, and answered a psychological stress questionnaire, prior to engaging in exergaming for 20 min/3d/wk. After 8 weeks, saliva and hair samples were re-taken, psychological stress re-tested, and exercise self-efficacy questionnaires administered. Results: Exergaming reduced salivary cortisol upon waking (0.24 ± 0.02 to 0.18 ± 0.01, $p < 0.05$) and 30-min later (0.45 ± 0.05 to 0.33 ± 0.03, $p < 0.05$) and hair cortisol (4.2 ± 0.4 to 2.6 ± 0.2, $p < 0.05$) as well as psychological stress and exercise self-efficacy in previously sedentary individuals.

Conclusion: Exergaming decreased both physiological and psychological stress. Exergaming should be considered a viable option for home exercise programs in an effort to help reduce stress and improve overall quality of life.

Keywords: *Exergaming; Stress; Self-efficacy; Cortisol; Quality of Life*

Abbreviations

ACSM: American College of Sports Medicine; COP: Center of Pressure; EG: ExerGaming; GHP: General Health Perception; HSIRB: Health Sciences Institutional Review Board; HPA: Hypothalamus, Pituitary Gland, Adrenal Glands; PAR-Q: Physical Activity Readiness Questionnaire; QoL: Quality of Life; SEM: Standard Error of the Means; SF-36: 36-Item Short Form Health Survey; SUNY: State University of New York; UB: University at Buffalo; YPAS: Yale Physical Activity Survey

Background

Interactive video game technology has been extensively utilized in rehabilitative settings [1-4]. However, few studies have explored the potential benefits of interactive video games as an exercise instrument for middle-aged adults who do not have a gym membership or who otherwise cannot regularly make it to their local fitness center. Features of interactive "exergaming" (modeling proper exercise bio-

mechanics, increasing self-monitoring of behavior, encouraging participants to set health related goals, and rewarding regular use) may help promote physical activity and consequently improve physiological and psychological stress response.

Aim of the Study

To establish the effects of an exergaming intervention on salivary and hair cortisol production, as well as on overall health perceptions, in a sedentary yet otherwise healthy middle-aged adult population.

Methods

Data collection

Sedentary but generally healthy men and women were recruited via the hanging of flyers in the local community and using social media listserv emails. Participants must have adequate vision and hearing to interact with games, not presently participating in an exercise program or utilizing Nintendo Wii or other exergaming platforms, no history of seizures or epilepsy, not taking specific medications with the capacity to influence cortisol production via several pathways affecting the HPA axis, no known hyper or hypocortisolism, no known contraindications for exercise. Prior to visiting the lab for the first time, potential participants were phone screened to assess their eligibility, and if deemed eligible, were required to provide informed consent prior to participation in the study. Once eligibility was established, the first lab visit screening occurred and required approximately 2 hours to complete. This screening visit consisted of the Informed Consent, anthropometric measures (height, weight, body fat % via the Bod Pod, Cosmed USA Inc., IL) and the SF-36 Health Survey was administered. The SF-36 is the most widely evaluated generic patient assessed health outcome instrument, measuring functional health and well-being. Hair and saliva samples were also collected to determine baseline cortisol levels. A saliva collection kit was given to each subject before and after the study consisting of six pre-labeled cryovials each containing a synthetic swab. Subjects were instructed to place the swab under their tongue upon waking, 30-minutes later, and as close to 4 pm as possible, without eating or drinking an hour prior to each collection. The swab was then placed in a -80°C freezer until completion of the study for subsequent immunoassay [5] (Salimetrics LLC, Carlsbad, CA). Hair was collected during the first study visit and again during the final visit. Hair strands totaling at least 5-cm in diameter were cut at the base of the vertex posterior of the head. Cut hair was then wrapped in aluminum foil labeled for proximal and distal ends, and then placed inside a paper envelope. Envelopes were stored in a locked filing cabinet inside assigned folders labeled with anonymous subject numbers until completion of the study for subsequent analysis [6] (Behavioral Immunology and Endocrinology Laboratory, University of Colorado Denver, Aurora, CO). The following eight weeks consisted of 20-minute exercise visits occurring three times per week. During these visits, participants conducted whole body metabolically demanding exercises by playing self-selected Nintendo Wii Fit games (Table 1) under the observation of trained personnel in a carpeted, well-ventilated lab. This room is conveniently located adjacent a water fountain and restroom and does not contain objects that participants could accidentally strike or fall into while exercising. Furthermore, this room is well lit, minimizing the risk of photosensitive epileptic seizures. Participants also documented any injuries and other events that occurred in their lives, which may adversely affect their performance in this study. The final study visit occurred back in the laboratory within one week of the last exercise visit and consisted of post-study measurements repeating the pre-study functional fitness tests and questionnaires from the first laboratory visit to allow for comparison. All experiments were performed in compliance with the relevant laws and institutional guidelines of the HSIRB.

Nintendo Wii Exercises	
Mode	**Options**
Aerobic	Hula Hoop, Basic Step, Synchronized Running, Rhythmic Boxing
Strength	Push-up, Side Plank, Front Lunge, Triceps Extension, Leg Raise
Balance	Table Tilt, Penguin Slide, Soccer Heading, Ski Slalom/Jump
Yoga	Palm Tree, Warrior, Downward-Facing Dog, Triangle, Roman Chair

Table 1: *Nintendo Wii Fit exercise options self-selected by study participants.*

Statistical analysis

The difference in outcome measures was analyzed using a two-way analysis of variance (ANOVA) with repeated measures using SigmaStat® software version 4.00 for windows (Systat Software, San Jose, CA). If statistical significance existed, a post hoc *t*-test with Holm-Sidak correction was used to determine the differences. A value of $p < 0.05$ was considered significant. All data are presented as means SEM except demographics, which are presented as means ± standard deviations.

Results

Subject characteristics

Subjects were recruited via flyers in the local community and using social media listserv emails. In total, 52 individuals initially expressed interest in participating in this study. Approximately half of those attended informational meetings and signed the Informed Consent form. Thirteen of those were fully qualified and subsequently enrolled into the study. Later, one of those individuals voluntarily dropped out following the initial screening visit citing a schedule that was too busy to participate. Consequently, 12 subjects fully completed all 26 study visits. Subjects' height, weight, and fat mass (Table 2) were typical of the average American middle-aged adult [7]. No subjects reported any significant changes to their health during the course of the study.

Subject Characteristics	
Age (years) 2 Males, 10 Females	56.6 **±** 3.6
Height (cm)	160.0 **±** 46.2
Weight (kg) pre-study	79.2 ± 19.1
Weight (kg) post-study	79.1 ± 19.2
Fat Mass (kg) pre-study	31.5 ± 10.0
Fat Mass (kg) post-study	31.6 ± 11.4
Fat Mass % pre-study	39.6 **±** 7.7
Fat Mass % post-study	39.5 ± 7.9
Ethnicity	
Caucasian	10
African American	1
Asian	1

Table 2: *Subject characteristics.*
Subject characteristics data represented as mean ± SD.

Cortisol

Saliva

Saliva samples were collected upon waking and 30-min later. There was a significant difference in cortisol levels before and after exergaming in both the waking sample (0.20 μg/dL ± 0.02 to 0.10μg/dL ± 0.01, $p = 0.03$) (Figure 1) and the sample collected 30-min after waking (0.40 μg/dL ± 0.05 to 0.30 μg/dL ± 0.03, $p < 0.001$) (Figure 2). These post-exergaming reductions reflect a 50% and 25% decrease respectively.

Hair

Cortisol levels were measured in the most proximal 3-cm segment of hair. There was a 38% decline after exergaming (4.2pg/mL ± 0.4 to 2.6pg/mL ± 0.2, $p = 0.009$) (Figure 3).

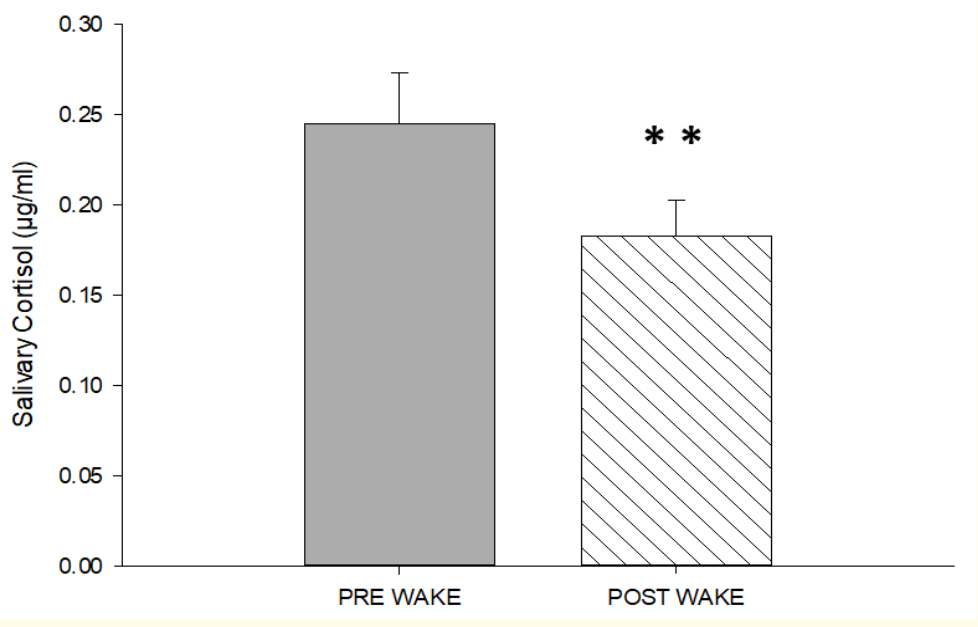

Figure 1: *Salivary cortisol upon waking pre and post-EG. Post-EG resulted in lower cortisol levels than pre-EG. Results represented as mean ± SEM, p = 0.03.*

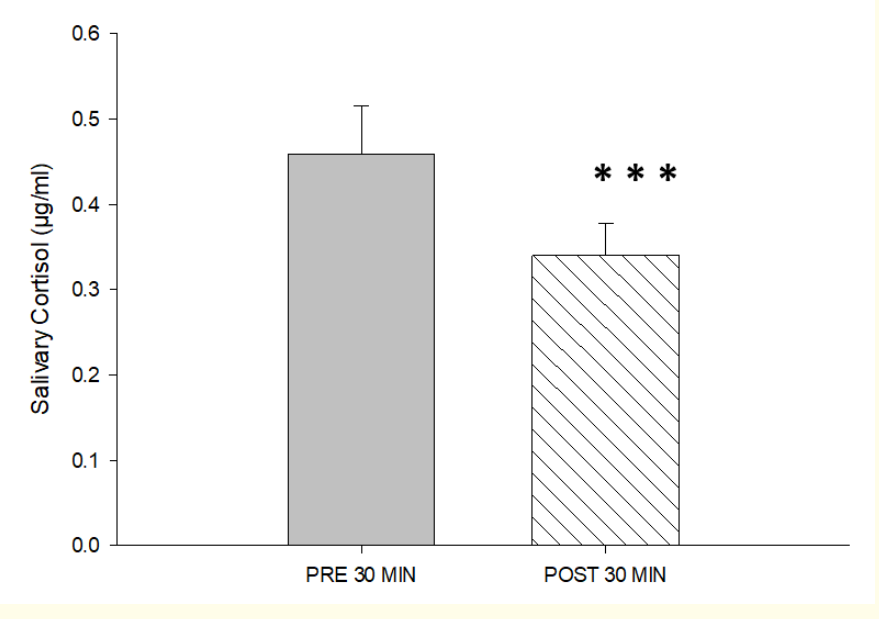

Figure 2: *Salivary cortisol 30-min after waking pre and post-EG. Post-EG resulted in lower cortisol levels than pre-EG. Results represented as mean ± SEM, p < 0.001.*

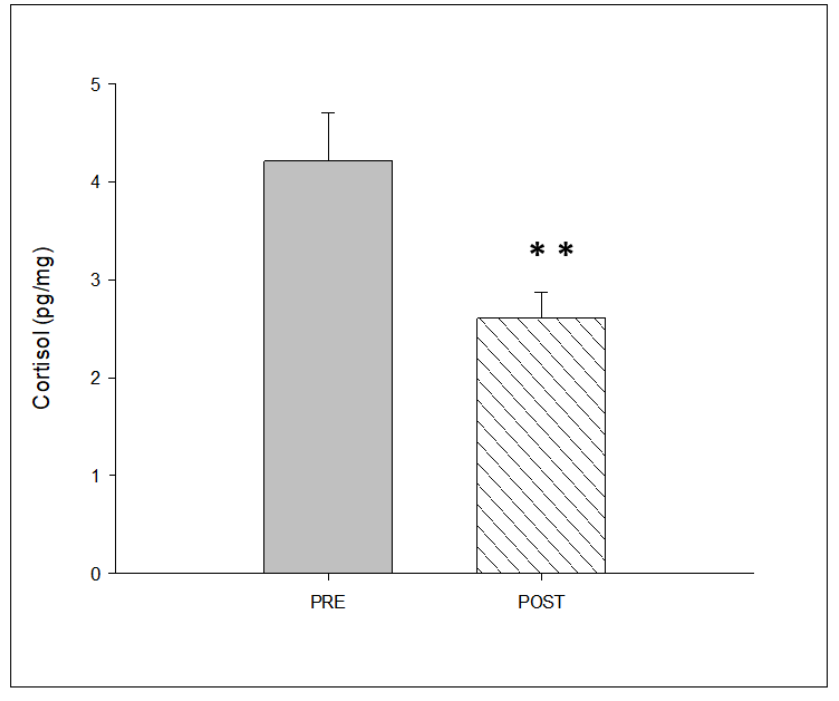

Figure 3: *Cortisol in the proximal 3 cm segment of hair pre and post-EG. Post-EG resulted in lower cortisol levels than pre-EG. Results represented as mean ± SEM, p = 0.009.*

Health perceptions

SF-36

The Short Form 36 Questionnaire measures quality of life through multiple self-reported questions regarding subjects' physical health, emotional health, and overall well-being. The SF-36 was administered before and after 8 weeks of exergaming. Post exercise intervention, there was an 11% increase in the Physical Functioning score (83 ± 3.2 to 92 ± 2.7, $p < 0.05$). We also observed an 18% increase in the General Health Perception score (62 ± 2.4 to 73 ± 2.9, $p < 0.05$).

Discussion

This study was designed to assess the effects of an exergaming intervention on self-reported health, as well as on salivary and hair cortisol production, in a sedentary yet otherwise healthy middle-aged adult population. After eight weeks, exergaming significantly enhanced participants' perception of their own physical functioning and overall general health. Exergaming also significantly improved participants' HPA-axis response to the physical and psychosocial stressors in their daily lives. This is an important finding since a continued escalation in allostatic load from HPA-axis hyperactivity is associated with the increased risk of developing hypertension [8], obesity [9], Type 2 diabetes [10], cardiovascular disease [11] and depression [12].

SF-36

We showed that exergaming resulted in higher ratings of self-reported physical functioning and overall general health. Based on the inherent qualities of questionnaires, responses could potentially be the result of mere subjective perceptions based solely on participating in a study investigating physicality and health. Indeed, MacNeil., *et al.* found that even during the initial stages of study participation,

subject awareness of their own unhealthy behaviors was raised, revealing evidence of subtle research participation effects which varied according to the health behavior and its perceived social acceptability [13]. French and Sutton concluded that the processes involved in taking part in research studies impacts participants' thinking and feelings about the targeted behaviors [14]. In the current study, participants were asked to keep their normal routines, and to report any deviations in physical activity or health status. Compliance was evaluated at every visit, 24 times over the course of 8 weeks. While no subject indicated an alteration in their daily patterns or health, there remains the possibility of a research participation effect influencing their perceptions, and thus ultimately their responses to the SF-36.

Beyond the effects of research participation, subjects could have truly felt healthier and fitter based on the Hawthorne effect. The Hawthorne effect is a type of reactivity in which individuals modify an aspect of their behavior in response to their awareness of being observed [15,16]. The original research from 1924-32 at the Hawthorne Works (a Western Electric factory outside Chicago) was commissioned to see if their workers would become more productive in higher or lower levels of light. The workers' productivity seemed to improve when changes were made and diminished when the study ended. It was suggested that the productivity gain occurred as a result of the motivational effect on the workers of the interest being shown in them. Later interpretations such as that done by Landsberger suggested that the novelty of being research subjects and the increased attention from such could lead to temporary increases in workers' productivity [17]. This interpretation was dubbed "the Hawthorne effect".

Systematic reviews provide evidence that answering research questions, as well as engaging in other parts of the research process, can and do have a modifying impact on study participants' behaviors [18,19]. Yet in the current study, only two of the eight specific activities measured by the SF-36 significantly changed, indicating that subjects did not alter their views merely as a result of study participation. These data suggest that while the Hawthorne effect cannot be totally discounted, post-intervention changes in perceived health and fitness were mediated, in part, by physiological changes from exergaming.

Cortisol

While subjects' perceptions and reactivity to participating in a research study are possible explanations to current observations, significant improvements to participants' physiological response to stressors were objectively measured. The current study was innovative as no studies have examined the stress response through salivary and hair cortisol production following 8-weeks of Nintendo Wii Fit game play. In summary, findings suggest that habitual participation in low to moderate-intensity exergaming elicits, on average, a lower level of cortisol in hair and saliva samples in middle-aged adults. This suggestion supports previous studies that have found low to moderate-intensity physical activity decreases circulating cortisol levels [20].

One important finding of the current study is that hair cortisol was not correlated to salivary cortisol. This is in concordance with Steudte and colleagues who revealed a non-significant correlation, $r = 0.27$, between hair cortisol and diurnal salivary cortisol [21]. A more robust analysis was conducted by Sauvé., *et al.* who found significant correlations between hair cortisol and 24h-urinary cortisol, $r = 0.33$, but not with plasma, $r = 0.06$, or morning salivary cortisol, $r = 0.31$ [22]. Irrespective of correlation across methodologies, hair cortisol showed a significant reduction after 8-weeks of exergaming, suggesting a physiological adaptation in the HPA-axis in response to stress.

These data also suggest a linkage between the SF-36 scales and the diurnal cortisol profile. Our findings of attenuated salivary cortisol production and improved SF-36 scores agrees with Hagger-Johnson., *et al*. who reported that salivary cortisol was associated with physical and mental components of SF-36 functional health status [23]. By connecting a health-related QoL measure such as the SF-36 to an objective measure such as salivary cortisol, our results provide further evidence that the SF-36 should be measured alongside cortisol in future research as they both capture important aspects of perceived and functional health status.

Conclusion

Discoveries include new findings on the reduction of salivary and hair cortisol production through exergaming. Additionally, exergaming improved psychological stress responses. Moreover, exergaming elicited a habitual voluntary moderate-intensity exercise level in

these previously sedentary participants. Interactive video game systems should be considered a viable option for convenient, enjoyable, in-home exercise programs to reduce stress and assist individuals in meeting ACSM physical activity guidelines. These discoveries add to the current literature concerning the reduction of stress and exercise barriers through interactive video games.

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Bibliography

1. Butler DP and Willett K. "Wii-habilitation: Is there a role in trauma?" *Injury-International Journal of the Care of the Injured* 41.9 (2010).
2. O'Meara M., *et al*. "Benefits of The Wii Video Game in Geriatric Communities". *Journal of the American Geriatrics Society* 59 (2011): S109-S110.
3. O'Donovan C and Hussey J. "Active video games as a form of exercise and the effect of gaming experience: a preliminary study in healthy young adults". *Physiotherapy* 98.3 (2012).
4. Chao YY., *et al*. "The feasibility of an intervention combining self-efficacy theory and Wii Fit exergames in assisted living residents: A pilot study". *Geriatric Nursing* 34.5 (2013): 377-382.
5. Salimetrics L. "Expanded Range High Sensitivity Salivary Cortisol Enzyme Immunoassay Kit". Salimetrics (2016).
6. Wright KD., *et al*. "Hair Cortisol Analysis: A Promising Biomarker of HPA Activation in Older Adults". *Gerontologist* 55 (2015): S140-S145.
7. Prevention CfDCa. National Center for Health Statistics. CDC (2017).
8. Esler M., *et al*. "Chronic mental stress is a cause of essential hypertension: Presence of biological markers of stress". *Clinical and Experimental Pharmacology and Physiology* 35.4 (2008): 498-502.
9. Vicennati V., *et al*. "Stress-related Development of Obesity and Cortisol in Women". *Obesity* 17.9 (2009): 1678-1683.
10. Pouwer F., *et al*. "Does emotional stress cause type 2 diabetes mellitus? A review from the European Depression in Diabetes (EDID) Research Consortium". *Discovery Medicine* 9.45 (2010): 112-118.
11. Dimsdale JE. "Psychological stress and cardiovascular disease". *Journal of the American College of Cardiology* 51.13 (2008): 1237-1246.
12. Lee S., *et al*. "Depression research: where are we now?". *Molecular Brain* 3 (2010): 8.
13. MacNeill V., *et al*. "Shedding light on research participation effects in behaviour change trials: a qualitative study examining research participant experiences". *BMC Public Health* 16 (2016).
14. French DP and Sutton S. "Reactivity of measurement in health psychology: How much of a problem is it? What can be done about it?". *British Journal of Health Psychology* 15 (2010): 453-468.
15. McCarney R., *et al*. "The Hawthorne Effect: a randomised, controlled trial". *BMC Medical Research Methodology* 7 (2007).
16. Fox NS., *et al*. "Clinical estimation of fetal weight and the Hawthorne effect". *European Journal of Obstetrics and Gynecology and Reproductive Biology* 141.2 (2008): 111-114.
17. Landsberger HA. Hawthorne Revisited. In. Ithaca (1958).

18. McCambridge J., *et al*. "The Effects of Demand Characteristics on Research Participant Behaviours in Non-Laboratory Settings: A Systematic Review". *Plos One* 7.6 (2012).

19. McCambridge J., *et al*. "Systematic review of the Hawthorne effect: New concepts are needed to study research participation effects". *Journal of Clinical Epidemiology* 67.3 (2014): 267-277.

20. Hill EE., *et al*. "Exercise and circulating cortisol levels: The intensity threshold effect". *Journal of Endocrinological Investigation* 31.7 (2008): 587-591.

21. Steudte S., *et al*. "Decreased hair cortisol concentrations in generalised anxiety disorder". *Psychiatry Research* 186.2-3 (2011): 310-314.

22. Sauve B., *et al*. "Measurement of cortisol in human hair as a biomarker of systemic exposure". *Clinical and Investigative Medicine* 30.5 (2007): E183-E191.

23. Hagger-Johnson GE., *et al*. "The SF-36 component summary scales and the daytime diurnal cortisol profile". *Quality of Life Research* 19.5 (2010): 643-651.

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