International Conference on Virtual Rehabilitation 2011
Rehab Week Zurich, ETH Zurich Science City, Switzerland, June 27 - 29, 2011

Energy Demands of Individuals Post-Stroke During Interactive Video Gaming

M. Kafri, M.J. Myslinski, J.E. Deutsch
Rivers Lab, Dept of Rehab & Movement Science, UMDNJ
Newark, NJ
kafrimi@umdnj.edu deutsch@umdnj.edu

Abstract- **Off-the-shelf interactive video games are used in the rehabilitation of individuals post-stroke. However, the potential benefits of using the games for aerobic training have not been tested. The purpose of this preliminary study was to determine feasibility of measuring energy expenditure during interactive video gaming by individuals post-stroke and to characterize the energy demands of specific games. We used indirect calorimetry to measure energy expenditure of one healthy and two post-stroke individuals under four conditions: rest, Wii Fit™ Long Run, Penguin, and Wii Sports™ Boxing. We found that measuring interactive video gaming of people post-stroke was feasible and required mild to moderate exercise activity.**

Keywords: Interactive video games, stroke rehabilitation, aerobic capacity, physical training

I. Introduction

Off-the-shelf interactive video games have been used as a tool to promote motor recovery of individuals post-stroke [1-6]. While the emphasis has been on recovery of neuromuscular components the potential metabolic benefits of gaming have not been tested. Energy expenditure (EE) of playing interactive video games in sedentary populations was tested and is distributed over a wide range intensity levels [7-9]. Given that individuals post-stroke are often de-conditioned we hypothesized that energy demands of gaming would be greater for them relative to those measured in healthy sedentary individuals. To promote aerobic training using interactive gaming for individuals post stroke, the energy demands of the games should be characterized. The purpose of this preliminary study was to 1. Test the feasibility of measuring metabolic demands of interactive video gaming of individuals post-stroke and 2. To characterize the energy demands of playing the games by individuals post-stroke.

II. Methods

One healthy individual (female, 50 years old) and two males post-stroke; (S1: 58 and S2: 49 years old) participated. Energy demands were tested at rest in sitting and when playing three Nintendo Wii™ games; Wii Sports™ Boxing (dynamic balance and coordination with upper extremity emphasis), Wii Fit™ Long Run (dynamic balance and coordination with lower extremity emphasis) and Wii Fit™ Penguin (static balance). The games were selected based on their stepwise increase in energy demands. All participants had previous experience and were competent with playing the games.

Physiologic measures (energy expenditure and heart rate) were collected during a single session. Participants sat in a quiet environment for 10 minutes and, then played each game for 8 minutes. Games were played in the same order: 1. Long Run, 2. Penguin, 3. Boxing. Subjects rested in sitting for 8-10 minutes after each game for physiologic measures to return to baseline values. Oxygen consumption was collected during the whole session by indirect calorimetry using K4b 2 Cosmed portable gas analysis system (Cosmed, Inc.) [10]. Data were collected breath-by-breath. Heart rate (HR) was collected continuously using a Polar monitor (Kempele, Finland) integrated in the K4b 2 system. Means ± standard deviations (SD) values of oxygen consumption, and HR were calculated separately for the rest in sitting (based on the first block of rest in sitting), and for each game period. The mean value of each condition was calculated using all time points of the condition. Metabolic equivalents (METs) were calculated by converting oxygen consumption values based on the conversion that 1 MET equals 3.5 $mL \cdot kg^{-1} \cdot min^{-1}$ [11] and were used to express the energy demands of rest and each game. Mean MET values were assigned with intensity of physical-activity category based on a classification consists of 6 categories: rest, light, fairly light, moderate, heavy, maximal [12].

III. Results

All Participants achieved a plateau in oxygen consumption and in HR in each of the games within 2.5-3 minutes and were able to complete eight minutes of continuous activity.

Energy demands differed markedly between post-stroke participants during gaming. Fig. 1 summarizes METs values for rest and each gaming period.

Changes in MET values relative to rest were similar between all participants for Long Run (range from 3.9 to 4.7 METs) and Boxing (range from 3.6 to 4.6 METs), while for Penguin increases were 1.7 for the Healthy 1.6 for S1 and 2.9 for S2. (Fig. 1)

All participants reached the highest mean HR value in the Boxing game and the lowest in the Penguin game. Increases in HR relative to rest were similar across participants. Fig. 2 summarizes HR values of each gaming period.

978-1-61284-474-9/11/$26.00 ©2011 IEEE

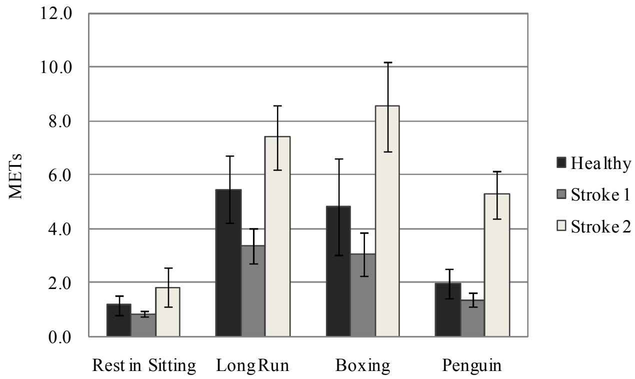

Figure 1: MET values while playing Wii games of all participants. Data are expressed as means ±SD of the condition period.

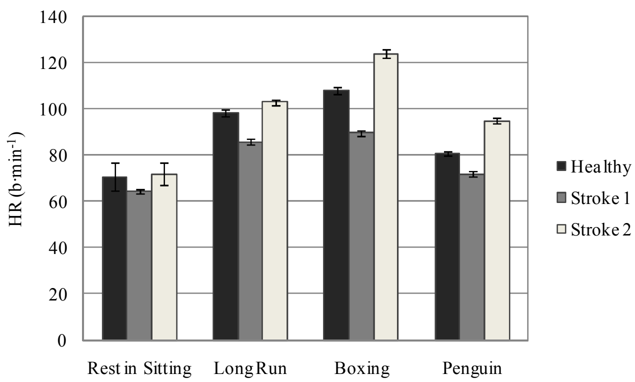

Figure 2: HR values while playing Wii games.
Data are expressed as mean ±SD of the condition period.

IV. Discussion

This preliminary study is the first to demonstrate the feasibility of metabolic measurements of individuals post-stroke while they engaged in interactive video gaming. The design of the study allowed collection of metabolic data of three different games. Participants tolerated the study protocol, were able to competently play the games and data collection was completed in all cases.

The findings of this preliminary study indicate differences among individuals post-stroke in their metabolic response to off-the-shelf interactive video games. S1 reached levels of physical-activity intensity that are considered light to fairly light while S2 reached levels of moderate-heavy intensity. Under the current protocol factors that may have contributed to this difference but were not explored are severity of impairments and body composition. Findings for the healthy subject are comparable to those reported in the literature (e.g. 2 and 2.2±0.4 respectively for the Penguin game and 4.8 and 4.2±0.9 respectively for the Boxing game, data as reported by Miyachi and colleagues [9].

The parametric response to exercise conditions differed between the healthy and post-stroke participants. While for the healthy participant intensity level for each game had an upward progression with the Penguin having the lowest demand and the Long Run the highest; for post-stroke participants energy demands of Long Run and Boxing were in the same category of physical-activity intensity. Interestingly while we expected energy demands to be greater for the individuals post-stroke relative to the healthy control, this was only true for one of the subjects (S2).

Our data suggest that interactive video gaming has the potential to promote aerobic training for individuals post-stroke. We found that both the Long Run and Boxing games produced prominent increases in energy demands. Even a balance game such as the Penguin led to considerable increases in energy demands for one of the participants.

The results presented in this study are preliminary. Considerations for further study in addition to increasing the number of subjects can include randomization of condition order and procedures for data analysis. Based on the positive preliminary findings of this study the investigators are undertaking a larger study to characterize the energy demands of interactive video gaming for individuals post-stroke.

References

[1] Deutsch, J.E. and A. Mirelman, *Virtual reality-based approaches to enable walking for people poststroke.* Topics in Stroke Rehabilitation, 2007. **14**(6): p. 45-53.

[2] Flynn, S., P. Palma, and A. Bender, Feasibility of using the Sony PlayStation 2 gaming platform for an individual poststroke: a case report. J Neurol Phys Ther, 2007. **31**(4): p. 180-9.

[3] Rand, D., R. Kizony, and P.T. Weiss, *The Sony PlayStation II EyeToy: low-cost virtual reality for use in rehabilitation.* J Neurol Phys Ther, 2008. **32**(4): p. 155-63.

[4] Saposnik, G., et al., Effectiveness of Virtual Reality Exercises in STroke Rehabilitation (EVREST): rationale, design, and protocol of a pilot randomized clinical trial assessing the Wii gaming system. Int J Stroke, 2010. **5**(1): p. 47-51.

[5] Saposnik, G., et al., Effectiveness of Virtual Reality Using Wii Gaming Technology in Stroke Rehabilitation. A Pilot Randomized Clinical Trial and Proof of Principle. Stroke, 2010.

[6] Yavuzer, G., et al., "Playstation eyetoy games" improve upper extremity-related motor functioning in subacute stroke: a randomized controlled clinical trial. Eur J Phys Rehabil Med, 2008. **44**(3): p. 237-44.

[7] Graves, L.E., N.D. Ridgers, and G. Stratton, The contribution of upper limb and total body movement to adolescents' energy expenditure whilst playing Nintendo Wii. Eur J Appl Physiol, 2008. **104**(4): p. 617-23.

[8] Lanningham-Foster, L., et al., *Activity-promoting video games and increased energy expenditure.* J Pediatr, 2009. **154**(6): p. 819-23.

[9] Miyachi, M., et al., METs In Adults While Playing Active Video Games: A Metabolic Chamber Study. Med Sci Sports Exerc, 2009.

[10] Duffield, R., et al., Accuracy and reliability of a Cosmed K4b2 portable gas analysis system. J Sci Med Sport, 2004. **7**(1): p. 11-22.

[11] McArdle, W.D., V.I. Katch, and F.I. Katch, *Exercise physiology :nutrition, energy, and human performance* 7th ed. 2010, Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins.

[12] Bouchard, C., et al., Exercise, Fitness, and Health: A Consensus of Current Knowledge 1990, Champaign, IL: Human Kinetics.