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# The Effect of Exergaming on Vascular Function in Children

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**Objectives** To assess whether exergaming can induce measurable changes in heart rate (HR), energy expenditure (EE), and flow-mediated dilation (FMD) arterial function in healthy children.

**Study design** Fifteen children (8 males, 10.1 ± 0.7 years, body mass index 17.9 ± 2.4 kg.m$^{-2}$) undertook a graded exercise test and 2 × 15 minute exergaming sessions (Xbox 360–Kinect); high intensity exergaming (HiE, Kinect Sports–200 m Hurdles) and low intensity exergaming (LoE, Kinect Sports–Ten Pin Bowling). Brachial artery FMD, a measure of endothelial function and arterial health, was measured before and immediately after each exergaming intervention. Actihearts were used to measure EE and HR during game play and a physical activity enjoyment scale assessed enjoyment.

**Results** Average HR during HiE (146 ± 11 beats per minute) was greater than during LoE (104 ± 11 beats per minute, $P < .05$), a pattern reinforced by EE data (HiE 294.6 ± 75.2 J.min$^{-1}$.kg$^{-1}$, LoE 73.7 ± 44.0 J.min$^{-1}$.kg$^{-1}$, $P < .05$). FMD decreased after HiE ($P < .05$), whereas no change was observed following LoE. Subjects reported no differences in enjoyment between LoE and HiE.

**Conclusion** HiE, but not LoE, induced large HR and EE responses that were associated with effects on vascular function. This study suggests that an acute bout of HiE exergaming may provide a substrate for beneficial arterial adaptations in children. *(J Pediatr 2013;163:806-10)*.

Contemporary levels of physical inactivity and obesity are unacceptably high in children.[1] Less than one-half (41.2%) of primary aged boys and only 27.4% of girls meet the minimum recommended levels of physical activity (PA) required to maintain health.[1] New-generation active console games, or exergaming, utilizes player movement to control the game. In the recent Child and Adolescent Physical Activity and Nutrition survey,[2] exergaming was reported as the first choice of active play for boys and within the top 5 rated activities for girls in Western Australia. Exergaming may, therefore, provide an alternative to sedentary behaviors and potentially contribute to increases in PA and health, assuming that it induces physiological responses large enough to translate into measurable health benefits.

Vascular function, and specifically endothelial dysfunction, is regarded as an important measure of arterial health, prior to the development of gross morphologic signs and clinical symptoms of atherosclerosis.[3] Endothelial dysfunction can manifest in the first decade of life,[4-6] and improvement in endothelial function predicts improved cardiovascular prognosis.[7] Although traditional forms of endurance and resistance exercise induce beneficial adaptations in endothelial function,[5,8] it is not known whether exergaming modifies artery function. In this study, we utilized 2 intensities of exergaming, high intensity exergaming (HiE) and low intensity exergaming (LoE), to assess whether exergaming (Xbox 360–Kinect; Microsoft Corp, Redmond, Washington) can induce measurable changes in heart rate (HR), energy expenditure (EE), and flow-mediated dilation (FMD) arterial function.

## Methods

Fifteen children aged between 9-11 years were recruited through advertisement. All children who responded to our advertisement were eligible and recruited for the study. Signed consent was obtained from a parent/guardian, and assent was obtained from the participants. Ethics approval for this study was granted by the Human Research Ethics Committee of The University of Western Australia.

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|---|---|
| EE | Energy expenditure |
| FMD | Flow-mediated dilation |
| GXT | Graded exercise test |
| HiE | High intensity exergaming |
| HR | Heart rate |
| LoE | Low intensity exergaming |
| MET | Metabolic equivalent |
| PA | Physical activity |
| PACES | PA enjoyment scale |
| $VO_2$ | Oxygen consumption |
| $VO_{2peak}$ | Peak oxygen consumption |

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Participants attended 3 separate testing sessions. Two sessions consisting of bouts of HiE and LoE, and 1 session involved a graded exercise test (GXT). All sessions were completed at the same time of day in a temperature controlled laboratory in a counterbalanced order with at least 48 hours separating each visit. Participants were instructed to eat a standardized meal, to not participate in any strenuous exercise, and to not consume caffeine in the 24 hours proceeding the testing sessions.

To measure the vascular response to exergaming, vascular function assessments using FMD (described below) were performed before and after each gaming session. To ensure that postural differences during gaming did not alter the FMD response, we also assessed FMD prior to, and following 15 minutes of passive seating and standing.

Upon arrival to the laboratory, subjects height and weight were measured, and following a 20-minute supine rest period, baseline blood pressure and HR were recorded (Omron HEM–7211; Omron Healthcare, Kyoto, Japan).

The GXT was conducted on a motorized treadmill (VR3000; NuryTech Inc, Seoul, Korea) using 2-minute exercise and 1-minute rest periods. The participant's oxygen uptake was measured via a metabolic cart (Ametek Gas Analyzers, SOV S-3A/1 and COV CD-3A; Applied Electrochemistry, Pittsburgh, Pennsylvania). Following a familiarization period, the initial treadmill speed was set at 4 $km.h^{-1}$ with subsequent increments of 1 $km.h^{-1}$ until volitional exhaustion. Throughout the protocol, rate of perceived exertion was recorded in accordance with a 1-10 scale with a visual aid (the Pictorial Children's Effort Rating Scale).[9] A Polar HR monitor (RS200; Polar Electro, Oy, Finland) was also worn to assess real-time HR during the GXT.

Ventilation was recorded continuously and summarized in 15-second intervals (excess postexercise oxygen consumption) via a turbine ventilometer (Morgan, 225 A; Kent, England), calibrated using a 1L syringe. Peak oxygen consumption ($VO_{2peak}$) ($mL.kg^{-1}.min^{-1}$) was determined for each participant by summing the 4 highest consecutive 15-second oxygen consumption ($VO_2$) values.

Following a 20-minute supine rest period, vascular function was assessed using the FMD technique, as detailed by Thijssen et al.[3] Following a 1-minute recording of resting brachial artery diameter, a forearm cuff (WelchAllyn DS-66, child/small adult; WelchAllyn, Inc, Skaneateles Falls, New York), placed distal to the olecranon process, was inflated to 220 mmHg for 5 minutes. Diameter and blood flow recordings resumed 30 seconds before cuff deflation and continued for 3 minutes. This procedure was repeated immediately following the 15-minute passive sitting, passive standing, HiE, and LoE intensity to assess the acute impact of exergaming on vascular function.

The LoE and HiE sessions were designed to elicit either a low intensity or a high intensity response, respectively. Based on previous unpublished work from our laboratory, we selected games that required the lowest and highest rate of perceived exertion and EE. These were Kinect Sports–Ten Pin Bowling for the LoE condition and Kinect Sports–200 m Hurdles for HiE. Both exergaming sessions were 15 minutes in duration, as specified by game manufacturers, and participants were given verbal encouragement to continue playing at the appropriate intensity for the duration of the session.

**Table I. Subject characteristics for the entire study group and divided into groups by sex**

| | Entire group (n = 15) | Girls (n = 7) | Boys (n = 8) |
|---|---|---|---|
| Age (y) | 10.13 ± 0.75 | 10.00 ± .082 | 10.25 ± 0.89 |
| Height (cm) | 1.45 ± 0.08 | 1.42 ± 0.05 | 1.48 ± 0.11 |
| Weight (kg) | 38.38 ± 6.11 | 35.85 ± 6.45 | 40.59 ± 7.75 |
| BMI ($kg.m^{-2}$) | 17.94 ± 2.36 | 17.44 ± 1.99 | 18.38 ± 2.58 |
| $VO_{2peak}$ ($mL.kg^{-1}.min^{-1}$) | 47.38 ± 7.66 | 44.91 ± 4.82 | 49.55 ± 8.71 |
| Resting artery diameter (mm) | 2.84 ± 0.27 | 2.62 ± 0.15 | 3.02 ± 0.21* |
| Resting FMD (%) | 10.81 ± 3.07 | 10.91 ± 2.26 | 9.86 ± 2.97 |

*BMI*, body mass index.
Mean ± SD.
*$P < .05$ girl vs boy.

An Actiheart monitor (2011-06; CamNtech Ltd, Cambridgeshire, United Kingdom) was worn by the participants during each testing session. The device was calibrated for each individual's age, height, and weight. As per manufacturers' recommendations, the device was attached to the chest using electrocardiogram electrodes (3M Red Dot 2271; 3M HealthCare, London, Ontario, Canada); one was placed on the sternum and the other directly distal to the sternum at approximately 5 cm, both were at the level of the third intercostal space. Upon conclusion of each session, the data was downloaded onto a laptop for analysis.

The advanced EE setting was chosen to analyze each Actiheart recording. A branch model calculation was used to determine the EE from the accelerometry and HR data. Data from the GXT were used to provide individually calibrated EE for each 15 minutes of game play. Once analyzed, the data were refined to the time of testing, and the 15 minutes of gaming isolated for statistical analysis.

The PA enjoyment scale (PACES)[10] was administered immediately following each exergaming, and the graded exercise session to assess the subjects self- perceived levels of enjoyment, interest, and fun. The PACES scale has been validated for use in children with high test-retest reliability.[11]

To quantify the relative intensity level (as a %$VO_{2peak}$) of activity undertaken by each child during the exergaming bouts, steady state HR, EE, and $VO_2$ data collected during the GXT were entered into the ActiHeart software (CamNTech; CamNTech Ltd, Cambridgeshire, United Kingdom). The relationship between EE and $VO_{2peak}$ during the GXT was also used to calculate, for each individual, the $VO_{2peak}$ at which they exercised under each exergaming condition.

## Statistical Analyses

Statistical analysis was carried out using SPSS v. 18.0 (SPSS Inc, Chicago, Illinois). All data are expressed as mean ± SD unless otherwise specified. A repeated measure