Predictors of metabolic energy expenditure from body acceleration and mechanical energies in new generation active computer games

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RELEVANCE FOR COMPUTER SCIENCE IN SPORT

The following paper is an original research project which uses state of the art sport science physiological and biomechanical approaches to gain information about active computer games.

This project is found to be particular relevant for the field of computer science in sport, since biomechanical and physiological knowledge is required to model, track and understand human motion during computer game play.

Modelling, tracking and understanding of human motion based on video sequences, accelerometer measures or other sensors is a field of research of increasing importance, with applications in sports sciences, medicine, biomechanics, animation (avatars), surveillance, and computer games. Progress in human motion analysis depends on research in computer graphics, computer vision, biomechanics and physiology. Though these fields of research are often treated separately, human motion analysis requires an interaction of computer graphics with computer vision, which also benefits from an understanding of biomechanical and physiological constraints. The study requires knowledge of both sport science and computer science therefore it is an opportunity for the field of computer science in sport to bridge the gap between both disciplines. The primary goal would be to translate between specialists from computer science and sport science contributing to the subject of human motion analysis from different perspectives.

INTRODUCTION

Individuals that successfully overcome obesity often have difficulty maintaining weight, fitness and physical activity (Consolvo et al. 2006). Adolescents spent most of their leisure time in front of the computer or TV screen, excluding sleeping hours (Crespo et al. 2001) New generation active computer games use this time to stimulate movement. However, game design lacks fundamental knowledge about the correlation between energy expenditure and the body movement. It is questionable whether the very successful single arm movement tennis game (Nintendo, Wii Sports) consumes comparable metabolic energy as the whole body active game (Playstation, EyeToy Kinetic).

The purpose of the study is therefore to first report the differences in energy consumption, heart rate and kinematics between the Nintendo Wii tennis game and the EyeToy Kinetic whole body active game. Second, to define predictors of metabolic energy expenditure from body kinematics.

METHODS

17 subjects (age = 22.1 ± 2.57 y, BMI = 72.7 ± 18.5 kg/m^2) performed a 10 min Nintendo Wii tennis and EyeToy Kinetic waterfall game. The order of the games were randomized, second game started when heart rate was at rest level. On separate days before the intervention, subjects were familiarised with both games. Spiroergometry, heart rate (K4, COSMED) and whole body kinematics (Vicon MX-460) were measured. Metabolic energy expenditure was determined from spiroergometry. Segments acceleration and kinetic and potential energy were calculated from a 16 segment model shown in figure 2 with a mass distribution according to (Yeadon 1990). Multivariate analysis was calculated to find the best predictors for metabolic energy consumption from average segment kinetic and potential energies as well as segments acceleration.

RESULTS

Heart rate and energy consumption were significantly higher in EyeToy Kinetics whole body game ($p<0.001$) and ($p=0.003$) respectively. Best predictors for energy expenditure are shown in table 1. During EyeToy game play best predictor for metabolic energy consumption was the kinetic energy of the right thigh.

DISCUSSION AND CONCLUSION

The results show clearly that the EyeToy Kinetic whole body game consumes significantly more energy. This might be explained by the more intensive movement of the legs compared to the Nintendo console tennis game since right thigh movement (kinetic energy) was the best predictor for all subjects for the energy consumed in the EyeToy game. A sound physiological explanation is that large muscle mass is involved into leg movement. Game designers are therefore advised to increase average leg kinetic energy during game play to intensify the energy expenditure.

REFERENCES

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Crespo C.J. et al. 2001. Arch Pediatr Adolesc Med 2001: 155:360-365

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FIGURES

Figure 1: Subject on the left side is playing EyeToy Kinetic waterfall game in front of the projection of himself within the augmented reality world shown on the right.

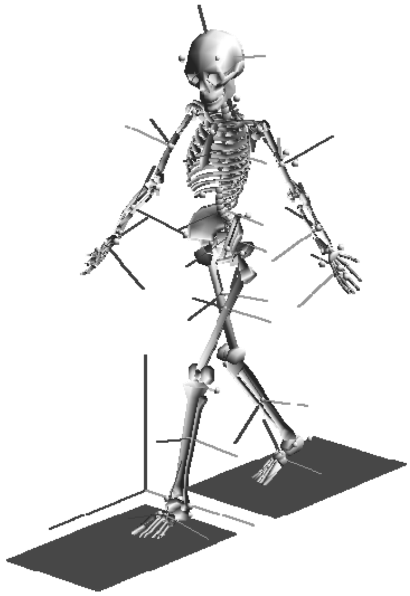

Figure 2: Rigid body model to calculate segment kinetic and potential energies and acceleration. It consists of 16 segments head thorax spine and pelvis and the right and left foot, shank, thigh, hand, forearm and up arm.

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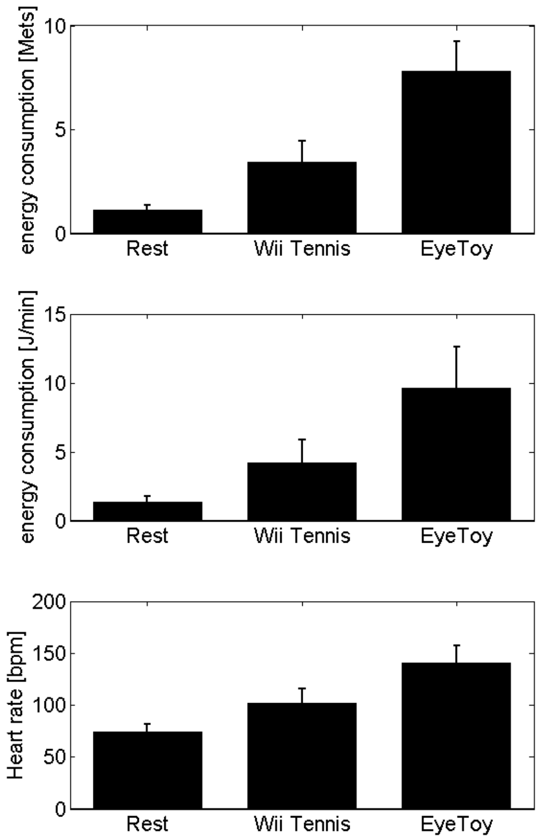

Figure 3: energy consumption and heart rate during rest, wii tennis and EyeToy kinetic waterfall game play

Table 1: predictors analysis

games	input parameters	R^2	best predictors
Wii Tennis	kinetic and potential energies	0.84	Ekin right forearm (β=0.59, p<0.001) Ekin left thigh (β=0.51, p<0.001)
	accelerations	0.80	right shank (β=0.60, p<0.001) right hand (β=0.52, p=0.001)
EyeToy Kinetics	kinetic and potential energies	0.75	Ekin right thigh β= (-1.45, p=0.006)
	accelerations	0.48	left forearm (β=0.68, p=0.015)