

# Active Video Games and Children With Cerebral Palsy: the Future of Rehabilitation ?

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**Abstract**—The aim of this study was to compare the aerobic solicitation and the postural movements induced by an active video game console in children with cerebral palsy, and in typically developing children. Results showed that the response varied greatly between games, emphasizing the importance of choosing the adequate game in order to solicit specific motor functions. Also, children with CP demonstrated strong interest and usually showed similar responses than their healthy counterpart, suggesting that active video game playing might be appropriate for motor rehabilitation.

*Cerebral palsy, active video game, energy expenditure, movement.*

## I. INTRODUCTION

Several adaptations explain the poor physical fitness and functional skills observed in children with cerebral palsy (CP): (1) reduced aerobic capacity, (2) poor motor function, and (3) inadequate postural control [1]. Unfortunately, therapies often address these problems separately, limiting their overall efficiency. We propose that the new generation of active video game consoles (AVGC) can efficiently solicit, (1) aerobic capacity (as shown in typically developing children [2]), (2) affected motor functions, and (3) postural control. The AVGC Nintendo Wii™ (Nintendo, Redmond, USA) allows individuals to interact with a virtual environment using an instrumented platform (Wii Fit™) and to play a variety of sport games. Some of them require balance skills, whereas others increase energy expenditure. AVGC can provide an important number of task repetitions, real-time feedbacks, a safe environment, and a high level of motivation which are key factors, associated with a successful rehabilitation. Despite the fact that this type of console is currently used in several rehabilitation centers, to date, no study has assessed the response induced by AVGC in children with CP. The goals of the present study are: (1) to compare the postural movements and the cardiorespiratory responses induced by AVGC in children with and without CP, (2) to evaluate the interest in AVGC games of children with and without CP, and (3) to determine the factors limiting AVGC playing in children with CP.

## II. METHODS

### A. Participants

Eleven children (aged 7-11 years) with diplegic spastic CP (GMFCS I-III) and 11 age-matched typically developing children (TD).

### B. Procedure

In a preliminary study, all Wii Fit™ games were first considered in order to identify suitable games for all children with CP (i.e. low cognitive requirements and appealing games) and involving important energy expenditure or postural control adjustments. Skiing and snowboarding games were selected because they induced large center of pressure displacements, whereas biking and jogging games were chosen because they led to a moderate/intense energy expenditure.

During the snowboarding and skiing games, the player stands on the Wii Fit™ and mainly shifts his body in the medio-lateral (ML) axis (skiing) or antero-posterior (AP) axis (snowboarding) in order to control the avatar in slalom trajectories defined by flags. For the jogging game, the player follows a guide by stepping with the remote in his pocket. During the biking game, players control the bikes direction and speed by tilting the remote or by stepping on the Wii Fit™ respectively, in order to reach the checkpoints.

Participants played 10 minutes with each of these four games (in a random order) with a 5-minute rest period between each game.

### C. Measurements

Various motor functions were first evaluated. Maximal isometric strength was measured at the hip, knee and ankle joints in flexion and extension using a hand held dynamometer (Lafayette inc, Lafayette, USA). Quiet standing postural control was also tested (3x40s). Center of foot pressure (COP) displacements were recorded on a force platform (AMTI, Watertown, USA) cadenced at 120 Hz. The sway parameters investigated were the COP range and the COP maximal velocity

along the AP and ML axes. Participants with CP also performed standing postural tests (2x20s) with each foot placed on separate juxtaposed force platforms in order to assess the adequacy of the postural asymmetry measurement provided by the Wii Fit™. Vertical component of each foot ground reaction force was expressed in percent of the participant's weight.

During skiing and snowboarding games, the COP displacement was recorded by placing the Wii Fit™ on a force plate. Outcome measures were the COP range along the AP and ML axes. Heart rate (HR) was also recorded during the entire playing period for all games with a HR belt monitor (Polar, Kempele, Finland). Exercise intensity was defined in percent of heart rate reserve (HRR = maximal HR-Rest HR). Rest HR was defined after a 10-minutes quiet lying period. For each game, time spent above 40% HRR was calculated. After each game period, participants completed the Borg Scale and a 10-point scale in order to quantify their rate of perceived exertion and their game's interest, respectively.

#### D. Statistics

Independent t-tests were used to evaluate the participant characteristic differences between groups. Two-way mixed ANOVA and post-hoc tests were performed to assess differences between groups and games. Pearson correlation coefficients (r) were calculated to quantify the relationship among the measures.

### III. RESULTS

Quiet standing postural control parameters did not vary between groups ( $p > 0.05$ ). Ankle dorsiflexion and hip flexion strength were lower ( $t = -2.42$ ;  $p = 0.026$  and  $t = -2.64$ ;  $p = 0.016$ , respectively) in children with CP compared to TD children.

Time spent at an intensity superior to 40% HRR did not vary between groups ( $F = 0.05$ ;  $p = 0.82$ ) but varied between games ( $F = 20.62$ ;  $p < 0.001$ ). Time spent at an intensity superior to 40% HRR was higher during the jogging game than during the biking game ( $p = 0.001$ ), which in turn was higher than the skiing ( $p = 0.027$ ) and snowboarding games ( $p = 0.024$ ) (Figure 1). Similarly, the Borg Scale values did not vary between groups ( $F = 0.59$ ;  $p = 0.45$ ) but varied between games ( $F = 8.29$ ;  $p < 0.001$ ). The jogging game's Borg scale score was superior to the three other games ( $p < 0.05$ ).

For the skiing and snowboarding games, the range of COP displacement in the AP axis did not vary between groups ( $F = 0.26$ ;  $p = 0.61$ ), but was higher during snowboarding compared to skiing game ( $F = 39.84$ ;  $p < 0.001$ ). No difference was observed in the ML axis between skiing and snowboarding games ( $F = 0.80$ ;

TABLE I HR and COP displacement during AVGC

Participants	COP range M/L (cm)		COP range A/P (cm)	
	Ski	Snowboard	Ski	Snowboard
CP	10.1(3)	9.9(2.2)	6.9(2.8)	12.6(5.4)*
TD	15.5(3) <sup>§</sup>	14.2(3.8) <sup>§</sup>	8.2(4.2)	12.5(3.7)*

Between games: \*,  $p < 0.001$ ; between groups: <sup>§</sup>,  $p = 0.001$

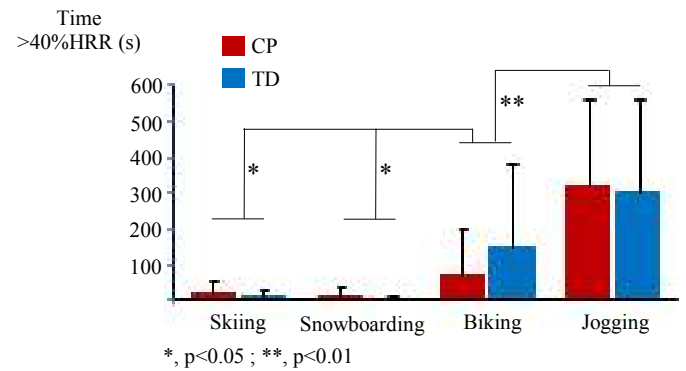


Figure 1. Time spend above 40%HRR

$p = 0.38$ ), whereas a significant difference appeared between groups ( $F = 16.51$ ;  $p = 0.001$ ) (Table 1). No significant difference was reported between games ( $F = 1.41$ ;  $p = 0.25$ ) and groups ( $F = 0.004$ ;  $p = 0.95$ ) concerning the satisfaction rate score (range 6.9-8.4).

The weight distribution on each foot measured with the Wii Fit™ was correlated with the force plate results ( $r = 0.71$ ,  $p < 0.05$ ), suggesting that the Wii Fit™ can be used as low cost precise and reliable device for measuring postural asymmetry.

### IV. DISCUSSION-CONCLUSION

This study shows that playing any of the four AVGC games led to similar energy expenditure in children with CP and in TD children. Therefore, the lower hip flexion and ankle dorsiflexion strength observed in the CP group compared to the TD group cannot be viewed as a limiting factor for increasing energy expenditure when they played AVGC. The jogging game was the most efficient game to increase energy expenditure; children spent half of this game's duration above 40% HRR, which meets the requirements for developing cardiorespiratory fitness. The present study also shows that the snowboarding game is very promising approach to adequately solicit A/P displacements. However, our results suggest that the solicitation of postural control in the ML axis using AVGC might be less efficient in patients with CP. This study clearly shows for the first time that the Wii™ is suitable for children with CP with moderate to high motor functions. AVGC should be viewed as a promising and playful approach to improve motor functions and aerobic capacity in CP.

### REFERENCES

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