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Examples of technology-aided programs to support physical activity in individuals with intellectual and multiple disabilities

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Abstract

This paper describes technology-aided programs for supporting (a) arm, leg or head responses, (b) assisted ambulation, (c) ambulation and occupational activities, and (d) basic physical exercise. Programs of the first type are designed for non-ambulatory individuals with intellectual disability. Programs of the second type are designed for individuals with intellectual disability and motor impairments, who are potentially able to ambulate with support. Programs of the third type are addressed to individuals with intellectual and visual disabilities who lack initiative and motivation to start ambulation and occupational activities on their own. Finally, programs of the fourth type are designed for individuals with intellectual and other disabilities who have the skills (but not necessarily the motivation) to use conventional exercise devices such as static bicycles.

Keywords: Technology-aided programs; Physical activity; Intellectual Disability; Multiple disabilities.

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1. Introduction

There is growing social and medical emphasis on the importance of engaging in regular physical activity to increase the chances of a healthy life and decrease the risk of health problems (Donnelly, Hillman, & Castelli, 2016; Kohn, Belza, & Petrescu-Prahova, 2016; Zhang, Xiang, & Gu, 2016). This emphasis is particularly pertinent and strong with regard to individuals with intellectual and multiple disabilities given that they generally have lower levels of physical activity and higher levels of physical concerns compared to their typical counterparts (Bartlo & Klein, 2011; Queralt, Vicente-Ortiz, & Molina-Garcia, 2016; Woodmansee, Hahne, & Imms, 2016; Dixon-Ibarra, Driver, & Vanderbom, 2017).

Increasing the level of physical activity of individuals with severe, profound or multiple disabilities may be a real challenge. Indeed, these individuals may be unwilling and/or unable to engage in relevant physical activity independently, and strategies need to be found to address their situation. One way to help these individuals may involve the use of technology-aided interventions directed at supporting the individuals' engagement in behaviors that (a) require physical exertion (and thus are helpful in terms of physical activity) and (b) produce positive environmental changes (capable of motivating the individuals to increase and maintain the performance of those behaviors) (Pierce & Cheney, 2008). This paper describes a few technology-aided programs aimed at supporting (a) arm, leg or head responses, (b) assisted ambulation, (c) ambulation and occupational activities, and (d) basic physical exercise.

2. Arm, Leg or Head Responses

For individuals who are affected by extensive motor impairments in addition to intellectual disability, physical activity may consist in the exercise/practice of the motor responses still available (e.g., arm or leg stretching). Typically, those responses are fostered by physiotherapists through physical guidance and verbal prompts. Despite its usefulness, the physiotherapist's approach is not enough. In order to enhance the individuals' practice of those responses, and at the same time increase their levels of physical activity, various forms of technology-aided programs may be developed. Those programs should promote the individuals' performance of the target responses independent of staff guidance or prompts, by delivering preferred (motivating/reinforcing) stimulation contingent on the occurrence of the responses. For example, Lancioni, Singh, O'Reilly, Sigafoos, Alberti, Campodonico and colleagues (2019b) developed a smartphone-aided program for seven participants (children and adolescents) who were confined in their wheelchairs and presented with intellectual disability and visual impairments. For each participant, two responses were selected: (a) right and left arm stretching to push a ball, (b) head raising and arm stretching to push a panel, and (c) arm stretching to push a panel and leg-foot movement to push a box. Each of these responses caused the light sensor of a Samsung smartphone positioned behind the ball, the panel or the box, and at the wheelchair headrest to be activated. The smartphone, which included an Android operating system automated via the MacroDroid application, reacted to the activation of its light sensor with the delivery of 10 s of preferred stimulation (e.g., songs). During the baseline phases, all participants had zero or near zero levels of responding. During the intervention phases (i.e., with the support of the smartphone-aided program), the participants' levels of responding showed very consistent increases. Significant increases were also observed in the participants' (a) heart rates (suggesting that the performance of the aforementioned responses amounted to mild/moderate physical exercise), and (b) indices of happiness (suggesting that the participants found the intervention sessions enjoyable).

Lancioni, O'Reilly, Sigafoos, Alberti, Campodonico and Chiariello (2019a) devised a smartphone-aided program aimed at promoting an arm-stretching response, which was required to put cards into an uplifted box. Such response was considered useful from a physiotherapeutic standpoint and adequate to cause physical exertion. The program relied on (a) a Samsung smartphone with Android operating system, which was automated through the MacroDroid application, and (b) cards fitted with frequency-coded identification tags. The smartphone was embedded in the uplifted box. When the participant placed a card into the box, the card touched the smartphone. The smartphone was activated by the card's tag and reacted by delivering 10 s of preferred stimulation. Seven adults with intellectual disabilities and extensive motor impairments participated in the study. Data showed a large increase in participants' responding during the intervention with the technology-aided program. A significant increase was also observed in the participants' heart rates and indices of satisfaction. The results just described were replicated in a subsequent study by Lancioni, Singh, O'Reilly, Sigafoos, Grillo, Campodonico and colleagues (2020) with six adults who used the same technology-aided program and the same response.

3. Assisted Ambulation

Independent or assisted ambulation represents a highly relevant education/rehabilitation objective for individuals with intellectual disability and motor impairments (Chang, Chang, & Shih, 2016). Ambulation can increase the individuals' opportunities of interaction and occupational engagement. Ambulation can also serve as a very important vehicle of physical activity/exercise. While there is ample consensus on the importance of this objective, strategies to help individuals with extensive disabilities are not always obvious. Fostering ambulation through staff support may represent only a temporary and partial solution. The use of technology-assisted programs may be a useful and practical alternative. For example, Lancioni, Singh, O'Reilly, Sigafoos, Oliva, Campodonico and colleagues (2013) developed a program to help three participants (two children and one adult) to ambulate to target places and manipulate objects through a four-wheel walker fitted with body weight lifting features and optic sensors. For two participants, each single foot step activated one of the sensors and caused a control device to produce 3 s of preferred stimulation. For the other participant, whose ambulation style consisted of moving with both feet simultaneously and produce a push forward, the stimulation followed each push response. During baseline, the participants showed only a few step or push responses thus failing to reach the target places. During intervention, all participants showed large increases in independent step or push responses and reached the target places successfully. One of the participants also displayed an increase in indices of happiness and a reduction of problem behavior.

Stasolla, Caffò, Perilli, Boccasini, Stella, Damiani and colleagues (2017) evaluated a program that matched the one by Lancioni and colleagues (2013) in terms of technology and procedural conditions. Two children with intellectual disability and motor impairment were involved. The results were in line with those reported by Lancioni and colleagues (2013). Both children had an increase in independent step responses and also displayed indices of happiness during the intervention sessions.

Lancioni, Singh, O'Reilly, Sigafoos, Alberti and Campodonico (2016) developed a program for a child with intellectual disability, blindness and spastic diplegia. The child was able to stand and make a few lateral steps when provided with support. The program relied on the use of a rail and a variety of optic sensors linked to a control device. Initially, the rail was 1-m long. The optic sensors were fixed on a panel behind the rail (to monitor lateral hand movements on the rail) and on the child's shoes (to monitor his foot movements). The child's activation of the first/next sensor behind the rail (via a rightward hand movement) caused 6-8 s of preferred stimulation provided that at least one of the shoe sensors was activated (i.e., provided that the child had made a lateral step movement). The technology also delivered occasional verbal encouragements. Reaching the end of the rail led the child to obtain social attention and extended access to preferred stimulation. As the child progressed in his walking, the distance between the sensors behind the rail was gradually increased and the length of the rail was also gradually extended to 2.5 m. Data showed that the child learned to ambulate successfully (i.e., reaching the end of the rail without any staff prompts and also fairly rapidly).

4. Ambulation and Occupational Activities

Individuals with intellectual and visual disabilities tend to be sedentary even when able to ambulate without difficulty. In fact, they tend to (a) have orientation problems causing them failure and frustration, and (b) lack initiative and motivation to start ambulation and occupational activities on their own. Given the situation, technology-aided programs may represent the best option to promote their active involvement in ambulation and occupational activities. These programs need to ensure that the participants (a) find the destinations for their occupational engagement, and (b) are motivated to continue their involvement in ambulation and occupational activities.

Lancioni, Singh, O'Reilly, Sigafoos, Alberti, Campodonico and colleagues (2017) evaluated a program to promote ambulation and occupational activities in eight adults with intellectual disability and blindness or minimal residual vision. The setting included four-to-six desks. Each desk, except the last, included several objects that the participants were to collect and transport to the last desk (putting them inside a container available on that desk). The technology available at each desk consisted of an electronic box with an optic sensor. The boxes served primarily to present auditory or visual orientation cues so that the participants could reach the desks with objects on display (i.e., to be collected). Once a participant reached a target desk, the optic sensor of the box detected him or her and the control system regulating the box caused the box to deliver brief positive stimulation. The participant was to collect one of the objects and then follow the orientation cues of the box of the last desk, which had just been automatically activated. When the participant reached this desk and placed the object in the container, the box started to deliver preferred stimulation for 20 s. The end of this stimulation period restarted the process. This was repeated for the rest of the session. Results showed that all participants were successful in their ambulation and occupational activity. All participants also had a significant increase of their heart rates during the intervention sessions.

Lancioni, Singh, O'Reilly, Sigafoos, Alberti, Chiariello and colleagues (2018a) evaluated a program similar to the one described above except for the use of conventional technology, which included (a) a smartphone with Android operating system and Bluetooth, (b) Bluetooth mini speakers, and (c) portable light sources. The smartphone was fitted with MacroDroid and fixed at the participant's waist or ankle. The Bluetooth speakers were located at the different destinations that the participant was to reach either to collect objects or to put away objects. The light sources were placed at the destinations so that they would trigger the smartphone's light sensor when the participant reached the destinations. Each activity sequence (i.e., collecting an object at a specific destination, transporting it to another destination, and putting it away there) started with the smartphone activating the speaker of the first destination (i.e., the one where the object was to be collected). The speaker provided verbal encouragements and other sounds to help the participant orient and ambulate to the right destination. When the participant reached the destination, the aforementioned cues were replaced by praise and the request to take the object. This was followed by the automatic activation of the speaker of the destination to which the object was to be transported. When the participant reached this destination (and the light source triggered the smartphone's light sensor), the orientation cues were replaced by praise, the request to put away the object transported, and 15-20 s of preferred stimulation. At the end of the stimulation, the smartphone started a new activity sequence. Data showed that the six adults participating in the study were unable to carry out activity sequences during the baseline but were highly successful with those sequences during the intervention with the smartphone-aided program.

5. Basic Physical Exercise

A most conventional way to increase physical activity/exertion relies on the use of exercise tools, such as static bicycles and stepper devices. The use of those tools may be viewed as appropriate and beneficial also for individuals with intellectual and other disabilities. Even so, questions exist regarding the motivation of these individuals to use the tools with intensity and continuity. Indeed, these individuals cannot appreciate the physical benefits of using such tools, as it is the case with typical individuals. Ensuring intensity and/or continuity through guidance and prompting might amount to a form of coercion and raise concern. A way to avoid concerns may involve the use of technology-aided programs that provide the participants with preferred stimulation in relation to their independent responses with these tools. For example, Lancioni, Singh, O'Reilly, Oliva, Campodonico and Groeneweg (2004) devised a program to increase the motivation of two participants (an adolescent and an adult) in using a static bicycle and a stepper. These tools were fitted with optic sensors that (a) monitored the participants' responses and (b) provided an input to a control system at each of those responses (i.e., at each completion of half cycle on the bicycle, and as a foot approached the ground on the stepper). Each input caused the control system to deliver 3 or 4 s of preferred stimulation. The results showed that, with the help of the program, each participant had significant increases in the response frequencies on both exercise tools. The participants also displayed an increase in their indices of happiness during the program sessions.

Chang, Shih and Lin (2014) used a static bicycle for two adolescents who presented with intellectual disability and were overweight or obese. The technology included an air mouse (sensor) fixed to one of the bicycle's pedal and a control system that detected the pedaling activity and ensured preferred stimulation in relation to such activity. The stimulation consisted of music videos delivered via a television set linked to the control device. The stimulation was played if the participants had a continuous pedaling activity, otherwise it was interrupted. Both participants showed a large increase in their pedaling behavior throughout the intervention phases of the study.

Lancioni, Singh, O'Reilly, Sigafoos, Alberti, Perilli and colleagues (2018b) extended the research described above with a group of 11 participants who used a static bicycle, a hand-pedaling kit, or a stepper. Each of these devices was used in connection with optic sensors and a control system, which regulated (a) the delivery of preferred stimulation contingent on the responses, and (b) the presentation of encouragements to respond after 10-15 s of nonresponding or at intervals of 25 s. During each intervention phase, all participants had a significantly higher frequency of responses than during the previous baseline period. Moreover, the heart rates of nine participants indicated that the intervention sessions amounted to a time of moderate physical exercise for them, with possible beneficial physical effects.

6. Conclusions

The programs summarized above represent a few examples of how the use of technology-aided solutions may support functional physical activity in individuals with intellectual and multiple disabilities. New research would be essential to (a) identify additional forms of physical engagement that could be feasible and plausibly useful for these individuals, and (b) develop additional forms of technology solutions that could be effective and convenient to foster such engagement.

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