Health Prob Civil. 2022, Volume 16, Issue 3
ISSN 2353-6942

EFFECT OF A METHOD FOR DEVELOPING COMMUNICATION SKILLS ON PHYSICAL ACTIVITY IN CHILDREN WITH INTELLECTUAL DISABILITIES

WPŁYW METODY ROZWIJANIA UMIEJĘTNOŚCI KOMUNIKACYJNYCH NA AKTYWNOŚĆ FIZYCZNĄ DZIECI Z NIEPEŁNOSPRAWNOŚCIĄ INTELEKTUALNĄ

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zebranie funduszy

Summary

Background. The purpose of the study is to evaluate the effectiveness of a selected special education method on the level of physical activity in schoolchildren with intellectual disability.

Material and methods. The study was conducted on 32 children with rather similar backgrounds: all participants were Armenians with no medical history of any registered disorders and the same moderate degree of intellectual disability (IQ score = 35-49). A physical education program based on two games using the Picture Exchange Communication System (PECS) was conducted for three months by a physical educator trained in PECS. The level of habitual physical activity before and after the study period was assessed by the Physical Activity Questionnaire for children (PAIC-A) and pedometry (Omron HJ-112, Illinois, USA). Two-way ANOVA (intellectual disability × intervention) with a post hoc Bonferroni test was used to examine the differences between the pre- and post-intervention physical activity and pedometry assessment results.

Results. The use of PECS resulted in an overall increase in the levels of physical activity. The results showed a significant group-by-time interaction effect for unstructured physical activity, structured exercise, organized sports, commuting to and from school, and total sedentary activities (all measured in min/week; $p<0.05$). Post hoc comparisons revealed a remarkable improvement in PAIC-A and pedometry scores in the intervention group ($p<0.05$).

Conclusions. Technologies for developing communication skills are an option to increase the physical activity of children with intellectual disability. Enhanced working memory facilitates improved executive motor functions.

Keywords: visual cueing, special education, learning disability, physical activity

Streszczenie

Wprowadzenie. Celem pracy jest ocena skuteczności wybranej metody kształcenia specjalnego na poziom aktywności fizycznej u dzieci w wieku szkolnym z niepełnosprawnością intelektualną.

Materiał i metody. Badaniem objęto 32 dzieci o dość podobnym pochodzeniu: wszystkie były Ormianami, bez historii medycznej jakichkolwiek zarejestrowanych zaburzeń i z takim samym umiarkowanym stopniem niepełnosprawności intelektualnej (wynik ilorazu inteligencji, IQ = 35-49). Program wychowania fizycznego oparty na dwóch grach wykorzystujących Picture Exchange Communication System (PECS) był prowadzony przez trzy miesiące przez pedagoga wychowania fizycznego przeszkolonego w zakresie PECS. Poziom nawykowej aktywności fizycznej przed i po okresie badania oceniano za pomocą kwestionariusza aktywności fizycznej dla dzieci (PAIC-A) oraz pomiaru liczby kroków (Omron HJ-112, Illinois, USA). Dwukierunkowa analiza wariancji ANOVA (niepełnosprawność intelektualna × interwencja) z testem post hoc Bonferroniego została wykorzystana do zbadania różnic między aktywnością fizyczną przed i po interwencji oraz wynikami oceny liczby kroków.

Wyniki. Zastosowanie PECS spowodowało ogólny wzrost poziomu aktywności fizycznej. Wyniki wykazały istotny efekt interakcji między grupą a czasem dla nieustrukturyzowanej aktywności fizycznej, ustrukturyzowanych ćwiczeń, zorganizowanego sportu, dojazdów do i ze szkoły oraz całkowitej aktywności sedenteryjnej (wszystkie mierzone w min/tydzień; $p<0{,}05$). Porównania post hoc wykazały znaczną poprawę wyników PAIC-A i pomiaru liczby kroków w grupie interwencji ($p<0{,}05$).

Wnioski. Technologie rozwijające umiejętności komunikacyjne stanowią opcję zwiększenia aktywności fizycznej dzieci z niepełnosprawnością intelektualną. Poprawiona pamięć robocza ułatwia poprawę wykonawczych funkcji motorycznych.

Słowa kluczowe: bodźce wizualne, edukacja specjalna, trudności w nauce, aktywność fizyczna

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Submitted: 2022 May 30
Accepted: 2022 Jul 1

Mkrtchyan H, Margaryan T, Hovhannisyan H, Petrosyan T. Effect of a method for developing communication skills on physical activity in children with intellectual disabilities. Health Prob Civil. 2022; 16(3): 246-257. https://doi.org/10.5114/hpc.2022.117830

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Introduction

Children with intellectual disabilities (ID) experience a variety of challenges in education. The social future of these children greatly depends on how they experience their early school years, which can affect the emotional, mental, and social development of these children. Children benefit greatly from a supportive learning environment and such support can lead to personal development and can enhance the emotional benefits of early childhood education. The inclusion of such children in schools and preschool institutions provides an opportunity to realize the full potential of intellectual as well as physical development [1,2]. The concept of inclusion in the education system encompasses all aspects of special education (including physical education). The communication delay in children with ID can lead to problems for their physical education. These children are unable to follow classroom procedures or to choose appropriate equipment for physical education classes. They have difficulties interacting with other children or participating in classroom discussions. In comparison with children with motor disorders, these children do not avoid contact but do have difficulties with communication, conditioned by their ID or lack of language skills [3,4].

Therefore, an attempt to use a tool for developing communication skills may have a cross-influence on communication and overall physical activity level. Literature reviews conducted by our research group and others have indicated that behavioral interventions can increase physical activity in youths with intellectual disability [5,6]. In addition to behavioral interventions, the approaches using communication therapy can yield similar cross-efficacy for communication and physical activity. This concept has not been discussed or presented in the literature on the subject.

Given that non-verbal, alternative methods of communication – especially the Picture Exchange Communication System (PECS) – have been widely used in communication therapy over the last few years, we have applied PECS in our study as a method for developing communication skills with visual cueing. This methodology was used on people of different ages with communication difficulties of various etiologies. In communication therapy, augmentative and alternative communication (AAC) tools are generally divided into two categories: low-tech and high-tech. Low-tech AAC comprises tools and strategies that do not involve electronics and do not require batteries. Examples of low-tech AAC are PECS, symbol charts, communication boards, communication books, etc. [7,8]. Today, PECS is successfully used in many countries [9-14]. The primary goal of this methodology is the development of functional communication skills, speech initiative, and spontaneous speech formation. With the help of PECS, the child learns to express wishes, thoughts, and – in time – emotions. In the PECS methodology, the pictures are not used in the traditional way: the child (or their partner) does not describe them, but instead forms a sentence and a story with the help of the pictures [15-18]. Whereas other, alternative communication systems (picture cards and activity schedules) rely on the teacher to initiate the communication, the advantage of PECS is that it does not simply use visual aids as the basis for communication, but initiates communication from the perspective of the nonverbal participant. This forces the students to interact with their peers and to be aware of their environment.

Additionally, individuals with ID have shown remarkable contextual facilitation of task performance in experiments with visual cueing; the level of facilitation was shown to be identical to that of the children with normal development scores [19]. PECS used as a visual cueing system may facilitate motor task performance in children with ID, as they do not exhibit a lack of facilitation in visual cueing models. Leah Ketcheson et al. have reported the positive effects of early motor skill intervention and increased physical activity on socialization outcomes in young children [20]. PECS could be an effective tool to not only improve communication in these children, but also increase their level of physical activity and enhance their socialization. Adults or adolescents with ID typically have participated in physical or cognitive therapy intervention programs and may have different baseline levels due to these interventions. To decrease the impact of confounding factors in our study, we restricted the age of the participants to 6-8 years.

Furthermore, the application of PECS in physical education not only supports student communication and self-determination, but also improves adaptive behaviors, increases the level of community engagement, and improves the quality of life [21-28]. A physical education teacher needs to complete a special training course in PECS, taught by an experienced professional [21,25]. They need to plan specific activities for students with ID. They are recommended to have an additional staff person available [21] when using PECS (phases I and II). The physical educator needs reinforcers (determining items of the physical education environment) and must prepare pictures of items within their environment. The use of PECS is not independent of the other teachers, but requires collaboration between them and the special educators.

The goal of the study is to determine the effects of PECS intervention in 6-8-year-old children with ID, as both an environmental language intervention strategy and a method to increase the level of physical activity. PECS could be an effective tool to increase the working memory of these children, thereby increasing their overall physical activity and facilitating socialization.

Material and methods

Participants

Thirty-two children (6-8 years old) with ID were involved in the study. They were divided into two groups: intervention and control. The sample size was not large, as we followed a list of criteria for the inclusion in the study. The two groups were equivalent in terms of their ID. The background of these children was rather similar and was based on the inclusion criteria: all of them were citizens of Armenia, their medical histories did not contain any registered disorders, they had the same moderate degree of ID (IQ score = 35-49) [29], they were able to independently follow an exercise intervention, and they had attended structured physical education classes in the previous three months. The children with ID were excluded from the study if they had other comorbidities (neurological, cardiac, respiratory, or musculoskeletal), had experienced a trauma in the previous six months, had significant cognitive impairment (or psychiatric conditions), or if they have taken part in any behavioral, physical or other type of therapies.

The intervention group (n=16) was matched with control group members (n=16) according to age, gender, body mass index (≤85th percentile), language dominance in the family, and connected speech level. In the physical education class where the controls were involved, the educator tried to engage the children with ID in the class activities with gesture manipulations or action demonstrations (by the educator or a peer).

In order to reduce the age span of the participants and avoid potential bias, we set the age limit to 6-8 years. There was no interaction between the intervention and control group members.

A stratified, cluster-sampling design was used in the study. Schools with inclusive education were the clusters sampled from strata of the districts. Inclusive education schools were selected by probability proportional to size sampling without replacement. The study was conducted in two schools with inclusive education, located in the Kotayk district, Armenia. For convenience, children were recruited to the intervention group from randomly selected classes, while the control group children were from different classes. The classes were selected randomly; in a physical education class, there were either intervention or control group participants. Restricted block randomization was used in the study, so participants were assigned to the intervention and control groups in a balanced manner.

PECS in physical education classes

Physical education sessions (45 minutes for each session with PECS) were conducted by a trained physical educator twice a week for three months. The physical educators prepared pictures of items within their environment and included them into a picture book. The teachers applied special teaching strategies when progressing through the six phases of the PECS methodology. The first phase comprises picture and item exchange and the communicative partner needs an assistant. In phase two, the space between the child and the picture is increased. The child learns to demonstrate more initiative than in the first phase. In the phase three, there is a choice between two or three pictures. The student goes to the communication book, selects an appropriate picture from the set, goes to the communication partner, and gives it to them. In phase four, the focus is on sentence structure. A strip for sentence formation is added to the communication book. In phase five, the child learns to express their wishes and answer the question "What do you want?". The target of this phase is a spontaneous choice of the preferred item among others. In phase six, the final one, there are responses to the different questions and instructions [30].

The physical education sessions consisted of three standard stages: a warm-up (10 min), the main phase (30 min), and a cool-down (5 min). During the warm-up and cool-down stages, the physical educator instructed the students using PECS to perform free exercises. The main part of the session included physical education games. We selected two games to use in the sessions: balloon blitz and garbage ball [31]. The games are rather time-consuming, particularly in classes where children with ID are involved, because the instructions take a long time and it requires a great deal of time and effort to control a class at this age.

PECS books (Figure 1) used by special physical educators include pictures of items used for physical education games as well as pictures showing movements (exercises, game components, and gross motor skills).

Figure 1. Portable PECS book with Armenian cards representing examples of gross motor skills and the sentence strip

Balloon blitz is an appropriate game for students of elementary school. This game improves coordination, enforces the importance of teamwork, and provides vigorous activity for children. Instructors will need a noodle for each student as well as about 40-50 balloons. The playing field is set up with cones and the goals (or trash cans) should be placed at the edge of the field. The group should be divided into two. Each team has to select a goalie to defend its goal. The objective of the game is to use the noodles to hit the balloons into the goal of the opposing team. The team that has the most balloons in the goal at the end of the game is the winner.

Garbage ball improves children's motor skills. The children should be split into two teams and given the exact same number of balls to throw. The teams are not allowed to cross the line in the center of the playing field. After a whistle, the teams can grab the "garbage" (balls) and throw it to the other team's side. When the whistle blows again, the team with the least amount of garbage of their side is the winner.

In the warm-up and cool-down (10 and 5 min, respectively) the physical educator uses PECS methodology to explain the free exercises for the students. This requires less time than the games, as the students of the group do not need any interaction (no need for connected speech improvement). On the contrary, the group games require active interaction between the group members to increase their chances of success. The classes consist of 22-25 children on average, so those with ID in the physical education class have to use PECS and form sentence strips when there is a need to communicate with their peers.

The game is explained once the physical educator does not need PECS-based instructions to initiate and control the game. PECS-based instructions not only explain the goal and rules of the game, but also provide training/coaching instructions on how to play better and interact with the other players.

Parent-reported physical activity of their child

The level of habitual physical activity (PA) before and after the study (the study lasted three months) was assessed by the PAIC-A questionnaire, administered to the parents of children with ID. The PAIC-A was adopted from the standardized Physical Activity and Nutrition in Children (PANIC) questionnaire [32], which assesses physical activity and nutrition in children; we excluded the nutrition part from the PAIC-A, as dietary intervention was not part of this study. Different activities are included in the questionnaire: organized sports, structured exercise, unstructured PA, commuting to and from school, and PA during recess.

The frequency of each type of physical activity and the duration of a session of each type of activity were recorded (in sessions per week and hours per session, rounded to the nearest 0.5 hour, respectively). The amount of each type of PA was determined by multiplying frequency by duration (expressed in minutes per day). The total PA was determined by summing the amounts of each type of PA (expressed in minutes per day). All children involved in the study had 90 minutes of physical education per week, which was included in the total PA. In order to assess the overall and differentiated increase in PA, the "unstructured" proportion of PA and "organized sports" outside of physical education classes were calculated, which revealed the changes not only in the "structured" PA, but also those in the domains of "unstructured" and "organized sports."

The validity of the PAIC-A questionnaire

The validity of an instrument assesses whether it actually measures the phenomena of interest. In other words, if the PAIC-A is designed to measure various aspects of physical activity in children with ID. Although many different types of validity have been proposed in the literature, not all methods are acceptable for assessing physical activity outcomes. Content validity indicates whether the questionnaire instrument appears logical to a group of experts. A panel of exercise physiologists, psychologists, experienced researchers with academic degrees in public health, and parents of participating children with ID (*n*=2 for each) evaluated the PAIC-A for content validity. The panel members used the questionnaire in a pilot survey with 10 patients (parents) and provided feedback on how well each item on the questionnaire measures the construct in a question. The evaluation addressed several key points: the goals of measurement (whether the PAIC-A measures patients' compliance and level of PA), the target population, the concepts (important aspects) targeted by the measurement, and the selection of questions, as well as concision (the relevancy of the questions) and interpretability. Additionally, the interface validity of the questionnaire was assessed. A language professor and a psychologist (both with PhDs) evaluated the logical sequence and appropriateness of items in the questionnaire. The purpose of the pilot testing was to test the questionnaire for clarity, comprehensiveness, and mean interview time. This procedure assesses the acceptability of the questions in order to reveal any potential problems in the interview process and to identify whether some other aspects which may be important for the questionnaire are missing. This stage of validity assessment was conducted in schools with inclusive education by the same interviewer. Ten children with ID were recruited by a consecutive sampling method to take part in the field testing. Agreement between observers assessing the level of physical activity was calculated by Cohen's kappa (K), wherein K>0.4 represents fair agreement and K>0.75 indicates excellent agreement.

Measurement procedure and protocol

On the first day of pedometry monitoring, the parents received a sealed pedometer and full instructions for the device. All participants in the study were instructed to attach the pedometer securely to the right waist in line with the mid-thigh using an elastic belt [33]. The subjects were also instructed to wear the device every day for seven consecutive days, from the time they woke up until the time they went to bed, excluding sleeping, bathing, and swimming, and to maintain their normal daily activities. Each morning at school, the researcher and assistants collected the pedometers, recorded the number of steps taken by the subjects, reset the pedometers to zero, prepared the pedometers for the next day, and returned them to the subjects. The parents of participating children provided a brief report to determine whether they had removed the pedometer for more than one hour during a given day. The data acquired from the children who reported removing their pedometers for more than one hour were removed from the data set. The pedometry data were downloaded and saved on a personal computer for analysis and data reduction. This protocol was similar to those followed in previous studies [33-35].

The number of steps for each child was measured using a pedometer (Omron HJ-112, Illinois, USA) for seven consecutive days. The Omron is a small, lightweight piezoelectric pedometer which indicates the total number of steps with a visual display that shows the current step count and has a button for resetting the count to zero [36-38]. The study day was considered valid when more than 10 hours of wear time were recorded by the observer/parent.

The patients' body weight was measured in bare feet and with minimal clothing. The body weight was measured thrice using an ISO 9001-certified bioimpedance scale (Tanita BC-601); the weight was rounded to the nearest 0.1 kg. The standing height was measured thrice, with the children in bare feet and standing straight against a wall using a calibrated measuring rod; the height was rounded to the nearest 0.1 cm. Using this data, BMI values were calculated for all the children. This number can be converted to an international percentile in order to define each child as normal (<85th percentile), overweight (85^{th}-95th percentiles), or obese (95th percentile) [39].

Ethics

The study was approved by the institutional review board, the Ethics Committee of the Armenian State Institute of Physical Education and Sports (approval no. 18AN:HU-psych-2023). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committees and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants in the study (their parents).

Statistical analysis

Two-way ANOVA (intellectual disability × intervention) with a post hoc Bonferroni test was used to examine the differences in the pre- and post-intervention PA levels and the mean scores of pedometry assessment. Differences were considered statistically significant if the *p*-value was ≤0.05. The bootstrapping method was used to generate more reliable confidence intervals. The data was sampled 1,000 times with replacement.

Results

Parent-reported physical activity in the children

The participants in the intervention and control groups were evaluated before and after the intervention. The evaluation process was conducted by the parents. The data were analyzed by the researchers (Table 1). The level of PA in all children of both groups was assessed with the PAIC-A questionnaire, a modified version of the standardized PANIC instrument [32].

Table 1. Assessment of physical activity in the intervention and control groups

Experimental group		Intervention group (*n*=16)		Control group (*n*=16)	
Total physical activity, min/week	Initial assessment	753±162	(95% CI 674 to 832)	790±270	(95% CI 658 to 922)
	Final assessment	964±236	(95% CI 848 to 1080)	794±262	(95% CI 666 to 922)
Unstructured physical activity, min/week	Initial assessment	316±76	(95% CI 279 to 353)	328±98	(95% CI 280 to 376)
	Final assessment	412±114	(95% CI 356 to 468)	326±78	(95% CI 288 to 364)
Structured exercise, min/ week	Initial assessment	45±18	(95% CI 36.2 to 53.8)	42±15	(95% CI 34.6 to 49.4)
	Final assessment	60±18	(95% CI 51.2 to 68.8)	46±14	(95% CI 39.1 to 52.9)
Structured exercise, times/ week	Initial assessment	2±1	(95% CI 1.75 to 2.25)	2±1	(95% CI 1.75 to 2.25)
	Final assessment	2±1	(95% CI 1.75 to 2.25)	2±1	(95% CI 1.75 to 2.25)
Unstructured exercise, times/ week	Initial assessment	5±1	(95% CI 4.75 to 5.25)	5±1	(95% CI 4.75 to 5.25)
	Final assessment	5±1	(95% CI 4.75 to 5.25)	5±1	(95% CI 4.75 to 5.25)
Organized sports, min/week	Initial assessment	63±16	(95% CI 58.9 to 67.1)	56±18	(95% CI 47.2 to 64.8)
	Final assessment	98±24	(95% CI 86.2 to 110)	64±18	(95% CI 55.2 to 72.8)
Commuting to and from school, min/ week	Initial assessment	128±34	(95% CI 111 to 145)	132±36	(95% CI 114 to 150)
	Final assessment	140±32	(95% CI 124 to 156)	142±34	(95% CI 125 to 159)
Total sedentary activities, min/ week	Initial assessment	1605±402	(95% CI 1410 to 1800)	1594±386	(95% CI 1410 to 1780)
	Final assessment	1452±342	(95% CI 1280 to 1620)	1562±274	(95% CI 1430 to 1700)
Total electronic media time, min/ week	Initial assessment	748±182	(95% CI 659 to 837)	759±174	(95% CI 674 to 844)
	Final assessment	642±178	(95% CI 555 to 729)	726±186	(95% CI 635 to 817)

Notes: Results are presented as means with standard deviation and bootstrapped confidence intervals.

The intervention (physical education including two games organized by the special educator and based on PECS) was conducted for three months (twice per week). A longer period was not used because the initial three-month period can show the possible difference, while further evaluation may only confirm whether the level of physical activity is maintained. Using a longer study period can potentially lead to lower enthusiasm in the children.

The two-way ANOVA analysis of PA data revealed no significant effect of the group-by-time interaction for the variables of total electronic media time and structured and unstructured exercise frequency (p=0.43, p=0.62, and p=0.56, respectively). However, there was a significant group-by-time interaction effect for the variables of unstructured physical activity (p<0.05), structured exercise (p<0.05), organized sports (p<0.05), commuting to and from school (p<0.05), and total sedentary activities (p<0.05). Post hoc comparisons (Bonferroni test) showed that the majority of the PA parameters were significantly higher in the intervention group (p<0.05) and that the total sedentary activity score was markedly lower (p<0.05).

Results of validity testing

The expert consensus revealed that PAIC-A has sound content validity. The participating experts agreed on all points of the validity testing: The PAIC-A is well structured and covers all important issues regarding the physical activity of children with ID. In their evaluation of the interface validity, the linguistic expert suggested vocabulary changes to make the questionnaire items more comprehensible. No significant changes were made to the structure of the questionnaire. Excellent agreement (K=0.90; 95% CI 0.78-1.02) in the assessment of the level of PA was found between observers. During the PAIC-A field testing, none of the participants refused to answer the questionnaire. All questions were perceived well by parents. The participants did not have any difficulty in the interpretation or comprehension of the questions. Answering the questions took 10 minutes on average.

Analysis of pedometry data

Table 2 shows the main total PA pedometry data (steps per day and weekday/weekend steps) and pedometer wear time (min/day) for the children in both groups. The results revealed that the intervention group members had significantly higher values than the children involved in regular program classes. For the weekend period, the children were more inactive and recorded lower values. The descriptive data of pedometry by group are presented in Table 2.

Table 2. Comparison of the pre- and post-intervention means of pedometry data, by group

Variable	Group	Assessment	N	Mean	SD	CI
Total PA (count/ min)	PECS	Initial	16	8.7	2.3	(95% CI 7.57 to 9.83)
		Final		13.8	2.8	(95% CI 12.4 to 15.2)
	Control	Initial	16	6.3	2.1	(95% CI 5.27 to 7.33)
		Final		7.6	2.4	(95% CI 6.42 to 8.78)
Steps (steps/day)	PECS	Initial	16	7321.4	2365.1	(95% CI 6160 to 8480)
		Final		9902.8	2814.2	(95% CI 8520 to 11300)
	Control	Initial	16	5532.2	1980.4	(95% CI 4560 to 6500)
		Final		5786.4	2223.4	(95% CI 4700 to 6880)
Weekday steps	PECS	Initial	16	6424.6	1426.3	(95% CI 5730 to 7120)
		Final		8192.8	2206.4	(95% CI 7110 to 9270)
	Control	Initial	16	4660.0	1108.6	(95% CI 4120 to 5200)
		Final		4912.6	1124.4	(95% CI 4360 to 5460)
Weekend steps	PECS	Initial	16	9240.4	3668.4	(95% CI 7440 to 11000)
		Final		13 186.6	4348.2	(95% CI -2120 to 2140)
	Control	Initial	16	6189.3	2624.4	(95% CI 4900 to 7480)
		Final		6325.5	3410.2	(95% CI 4660 to 8000)
Wear time (hours/ day)	PECS	Initial	16	12.14	1.8	(95% CI 11.3 to 13)
		Final		12.26	1.8	(95% CI 11.4 to 13.1)
	Control	Initial	16	11.26	2.4	(95% CI 10.1 to 12.4)
		Final		11.32	2.0	(95% CI 10.3 to 12.3)

As with the PA data, the analysis of pedometry data by two-way ANOVA revealed no significant effect of the group-by-time interaction for total electronic media time or structured or unstructured exercise frequency (*p*=0.55, *p*=0.68, and *p*=0.62, respectively). However, there was a significant group-by-time interaction effect for the variables of unstructured physical activity ($p<0.05$), structured exercise ($p<0.05$), organized sports ($p<0.05$), commuting to and from school ($p<0.05$), and total sedentary activities ($p<0.05$). Post hoc comparisons (Bonferroni test) showed that the PA parameters had markedly improved in the intervention group ($p<0.05$). The results demonstrate that the intervention group children were more active than the children in the control group ($p<0.05$). There were significant differences in the total number of steps per minute between the children in the intervention group and the control group ($p<0.0001$).

Discussion

This work presents examples of adaptive game design aimed to support the development of cognitive and motor skills in children with intellectual disabilities. The selected method can not only develop specific motor skills, but can also stimulate the overall physical activity of children with intellectual disability. In addition, the study introduces a new approach for physical education specialists that suggests using a method for developing communication skills in the physical education of children with ID.

Special variables were selected in order to assess the effect that the method for developing communication skills has on the PA of children with ID. The assessment of children in the intervention and control groups revealed non-homogeneous changes in the selected variables. The absolute scores of structured PA were much higher because the intervention recruited the children in physical education classes. The absolute scores for the organized sports activities were higher in the intervention group, yet more of an increase was observed in the category of "unstructured" physical activity. This category shows the overall activating influence of the structured intervention on the scores of general and unstructured physical activity. Two-way ANOVA with a post hoc test was used to estimate the changes in group score during the testing period. The results for both PA assessment and pedometry showed no significant effect of the group-by-time interaction for total electronic media time or structured or unstructured exercise frequency ($p>0.05$). A significant group-by-time interaction effect was estimated for unstructured physical activity, structured exercise, organized sports, commuting to and from school, and total sedentary activities ($p<0.05$). Post hoc comparisons (Bonferroni test) revealed a remarkable improvement in the PA and pedometry scores in the intervention group ($p<0.05$). The mechanism of such improvement may be the positive reinforcement from PECS in children with ID, facilitating their adaptation to the gradually increasing difficulty levels or loads in physical education classes and developing the motor skills required for the game, to be used later in other daily activities.

Research suggests that different modalities of sensory cueing (symbols on the floor, images, or light signaling) lead to improvement in the motor performance of different categories of patients with neurological disorders. Several studies have indicated improvements in stride length and walking speed when using visual cues on the floor [40,41]. Pongmala et al. concluded that visual and somatosensory cues can improve gait in patients with Parkinson's disease [42]. Other researchers have shown that on-demand cueing could be more effective in reducing the duration of freezing episodes than other modalities [43]. A virtual reality system was developed for rehabilitating patients with hemispatial neglect, where dynamic cueing is effective in encouraging patients to focus their attention on the neglected side [44]. However, these open-loop feedback systems may not have long-term benefits unless dedicated training programs are established [45]. Closed-loop feedback systems, a subtype of which we used in this study, may lead to the long-term learning of motor skills and enhanced adaptive cerebral plasticity, particularly with the use of visual cueing [46]. The mechanism behind the overall increase in the physical activity of children may be explained by the activation of cognitive resources through exercise and movement patterns. The learned motor maneuver codes persist in the brain for any working memory task. Exercise or games impose a supplementary demand on attention, enhancing the memory maintenance activities [47]. The exercise maneuvers in low-demanding children require the involvement of some attentional resources in order to control the motor program precisely. In executive motor tasks, visual cues that were provided to facilitate the maintenance of the goal have been shown to reduce goal neglect. Visual cues have been thoroughly studied in the field of motor executive functions. By presenting an image related to the goal, children improve their executive motor functioning [48]. Well-programmed cueing favors goal maintenance. PECS served as a form of visual cueing for the children with ID to improve communication or attention as well as motor performance. The method based on visual cueing is believed to have a positive influence on the temporal parameters of movements, appropriately increasing the amplitude of gait and leading to overall spatiotemporal stabilization [49]. In other studies, training with cues led to a significant improvement in several measures of gait-related outcomes in neurological patients [50,51]. This research suggests that the improvements in the intervention group are due to visual cue training.

The application of PECS in physical education sessions did not have a significant effect on the time of total sedentary activities and total electronic media time. The strength of the study is the novel approach to using technologies for alternative communication based on visual cueing to stimulate overall physical activity level. The physical education teachers showed a significant degree of acceptance of this communication skill development method, indicating that the adaptive games are understood as a tool that can be used by professionals who work with children with different types of cognitive or mental impairment to stimulate the development of motor skills and to increase overall level of physical activity. The application of symbols or PECS has the potential to develop a platform for designing a variety of adaptive games suitable for physical education. In addition, we intend to meet the suggestions made by study participants (children, educators, and parents), such as developing new types of games, modifying games, or changing the performance requirements.

This study has several limitations. These children predominantly attended inclusive education schools and were therefore unlikely to be representative of the broader population of children with ID. The advantage of having active participants with a lower level of ID is that they usually do not have concomitant motor disorders, in contrast to children with a higher level of ID studying in special schools. Further research should consider a larger number of participants with disability, including more targeted recruitment strategies for those who are enrolled in special education schools, are less active, and have more severe disability. Another limitation of the study is that some parents may have completed the survey without input from their child. A variety of environmental, socioeconomic, psychological, cognitive, demographic, biological and emotional factors, behavioral attributes, and skill factors may have led to a potential bias in the results [52], for example, the difference in total body fat percentage, difference in maximal workload per total body lean mass, and even the difference in parents' college or other higher vocational degree [53,54].

A further study with a much larger intervention group size (involving multiple schools) is necessary to confirm the results of our study showing an advantage of PECS over gestures or other cueing modalities. A larger intervention group may allow the researchers to look at the issue of physical activity in terms of all the above possible determinants.

Conclusions

Special education methods can serve as an option to improve the communication skills as well as the physical activity of children with intellectual disability. Enhanced working memory favors executive motor function and motor performance. Physical activity should be promoted in the initial stages of inclusive education in order to facilitate adequate integration of children with intellectual disability into the inclusive educational environment.

Disclosures and acknowledgments

The authors declare no conflicts of interest with respect to the research, authorship, and/or publication of this article. The research was funded in part by a research grant from the Armenian National Science and Education Fund (ANSEF) based in New York, USA.

References:

1. Blake Huer M. Individuals from diverse cultural and ethnic backgrounds may perceive graphic symbols differently: response to Nigam. Augmentative and Alternative Communication. 2009; 19(2): 137-140. https://doi.org/10.1080/0743461031000073083
2. Chung YC, Stoner JB. A meta-synthesis of team members' voices: what we need and what we do to support students who use AAC. Augmentative and Alternative Communication. 2016; 32(3): 175-186. https://doi.org/10.1080/07434618.2016.1213766
3. Hronis A, Roberts R, Roberts L, Kneebone I. Potential for children with intellectual disability to engage in cognitive behaviour therapy: the parent perspective. J Intellect Disabil Res. 2020; 64(1): 62-67. https://doi.org/10.1111/jir.12694
4. Aguayo V, Verdugo MA, Arias VB, Guillen VM, Amor AM. Assessing support needs in children with intellectual disability and motor impairments: measurement invariance and group differences. J Intellect Disabil Res. 2019; 63(12): 1413-1427. https://doi.org/10.1111/jir.12683
5. Petrosyan T, Mkrtchyan H, Martirosyan N. Can behavioral interventions increase physical activity in youth with cerebral palsy? A scoping review. Health Prob Civil. 2021; 15(4): 315-322. https://doi.org/10.5114/hpc.2021.110112

6. Stiles-Shields C, Crowe AN, Driscoll CFB, Ohanian DM, Stern A, Wartman E, et al. A systematic review of behavioral intervention technologies for youth with chronic health conditions and physical and intellectual disabilities: implications for adolescents and young adults with spina bifida. J Pediatr Psychol. 2019; 44(3): 349-362. https://doi.org/10.1093/jpepsy/jsy097
7. Borg S, Agius M, Agius L. A user and their family's perspective of the use of a low-tech vs a high-tech AAC system. Stud Health Technol Inform. 2015; 217: 811-818.
8. Alzrayer NM. Transitioning from a low- to high-tech Augmentative and Alternative Communication (AAC) system: effects on augmented and vocal requesting. Augment Altern Commun. 2020; 36(3): 155-165. https://doi.org/10.1080/07434618.2020.1813196
9. Baca L, Escamilla K, Carjuzza J. Language minority students: literacy and educational reform. In: Ellsworth NJ, Hedley CN, Baratta AN., editors. Literacy: a redefinition. Hillsdale, NJ: Lawrence Erlbaum; 1994. p. 61-76.
10. Beaumont C, Langdon HW. Speech-language services for Hispanics with communication disorders: a framework. In: Langdon HW, Cheng LL., editors. Hispanic children and adults with communication disorders. Gaithersburg, MD: Aspen; 1992. p. 1-19.
11. Bernstein DK. Assessing children with limited English proficiency: current perspectives. Topics in Language Disorders. 1989; 9: 15-20. https://doi.org/10.1097/00011363-198906000-00004
12. Hodgdon L. Visual strategies for improving communication: practical supports for school & home. Troy: Quirk Roberts Pub; 1995.
13. Tincani M, Devis K. Quantitative synthesis and component analysis of single-participant studies on the Picture Exchange Communication System. Remediation and Special Education. 2010; 32(6): 458-470 https://doi.org/10.1177/0741932510362494
14. Avagyan A, Mkrtchyan H, Alsadat Shafa F, Mathew JA, Petrosyan T. Effectiveness and determinant variables of augmentative and alternative communication interventions in cerebral palsy patients with communication deficit: a systematic review. CoDAS. 2021; 33(5): e20200244. https://doi.org/10.1590/2317-1782/20202020244
15. Petrosyan T, Mkrtchyan, H, Harutyunyan Z, Avagyan A. Preliminary assessment of the need and awareness of augmentative and alternative communication systems in Armenia. Iran J Public Health. 2019; 48(1): 173-175. https://doi.org/10.18502/ijph.v48i1.807
16. Binger C, Light J. The effect of aided AAC modeling on the expression of multisymbol messages by preschoolers who use AAC. Alternative and Augmentative Communication. 2007; 23: 30-43. https://doi.org/10.1080/07434610600807470
17. Calculator S, Dollaghan C. The use of communication boards in a residential setting: an evaluation. Journal of Speech and Hearing Disorders. 1982; 47(3): 281-287. https://doi.org/10.1044/jshd.4703.281
18. Miriam C, Boesch OW, Subramanian A, Hsu N. Comparative efficacy of the Picture Exchange Communication System (PECS) versus a speech-generating device: effects on social-communicative skills and speech development. Journal Augmentative and Alternative Communication. 2013; 29: 197-209. https://doi.org/10.3109/07434618.2013.818059
19. Merrill EC, Conners FA, Yang Y, Weathington D. The acquisition of contextual cueing effects by persons with and without intellectual disability. Res Dev Disabil. 2014; 35(10): 2341-2351. https://doi.org/10.1016/j.ridd.2014.05.026
20. Ketcheson L, Hauck J, Ulrich D. The effects of an early motor skill intervention on motor skills, levels of physical activity, and socialization in young children with autism spectrum disorder: a pilot study. Autism. 2017; 21(4): 481-492. https://doi.org/10.1177/1362361316650611
21. Liddle K. Implementing the Picture Exchange Communication System (PECS). International Journal of Language and Communication Disorders. 2001; 36: 391-395. https://doi.org/10.3109/13682820109177917
22. Shogren KA, Faggella-Luby MN, Bae SJ, Wehmeyer ML. The effect of choice-making as an intervention for problem behavior: a meta-analysis. Journal of Positive Behavior Interventions. 2004; 6: 228-237. https://doi.org/10.1177/10983007040060040401
23. Stoner JB, Beck AR, Bock SJ, Hickey K, Kosuwan K, Thompson JR. The effectiveness of the Picture Exchange Communication System with nonspeaking adults. Remedial & Special Education. 2006; 27: 154-165. https://doi.org/10.1177/07419325060270030401
24. Wehmeyer M, Schwartz M. The relationship between self-determination and quality of life for adults with mental retardation. Education and Training in Mental Retardation and Developmental Disabilities. 1998; 33: 3-12.
25. Howlin P, Gordon RK, Pasco G, Wade A, Charman T. The effectiveness of Picture Exchange Communication System (PECS) training for teachers of children with autism: a pragmatic, group randomized controlled

trial. Journal of Child Psychology and Psychiatry. 2007; 48: 473-481. https://doi.org/10.1111/j.1469-7610.2006.01707.x
26. Palacios-Navarro G, Albiol-Pérez S, García-Magariño García I. Effects of sensory cueing in virtual motor rehabilitation. A review. J Biomed Inform. 2016; 60: 49-57. https://doi.org/10.1016/j.jbi.2016.01.006
27. Haxby JV, Grady CL, Horwitz B, Ungerleider LG, Mishkin M, Carson RE, et al. Dissociation of object and spatial visual processing pathways in human extrastriate cortex. Proceedings of the National Academy of Sciences of the United States of America. 1991; 88(5): 1621-1625. https://doi.org/10.1073/pnas.88.5.1621
28. Goodale MA, Milner AD. Separate visual pathways for perception and action. Trends in Neurosciences. 1992; 15(1): 20-25. https://doi.org/10.1016/0166-2236(92)90344-8
29. Kolset SO. Intellectual disability and nutrition-related health. EMBO Mol Med. 2020; 12(10): e12899. https://doi.org/10.15252/emmm.202012899
30. Bondy A, Frost L. A picture's worth: PECS and other visual communication strategies in autism. Bethesda: Woodbine House Inc.; 2011.
31. Poppen JD. 201 games for the elementary physical education program. 1st edition. Castletown: Parker Pub Co; 2002. p. 232.
32. Väistö J, Eloranta AM, Viitasalo A, Tompuri T, Lintu N, Karjalainen P, et al. Physical activity and sedentary behaviour in relation to cardiometabolic risk in children: cross-sectional findings from the Physical Activity and Nutrition in Children (PANIC) Study. Int J Behav Nutr Phys Act. 2014; 11: 55. https://doi.org/10.1186/1479-5868-11-55
33. Pitchford EA. The accuracy of pedometers for adults with Down syndrome during controlled and free-walking conditions. [Dissertation]. Corvallis: Oregon State University; 2009.
34. Welk GJ, Corbin CB, Dale D. Measurement issues in the assessment of physical activity in children. Res Q Exerc Sport. 2000; 71(Suppl 2): 59-73. https://doi.org/10.1080/02701367.2000.11082788
35. Vincent SD, Pangrazi RP. An examination of the activity patterns of elementary school children. Pediatr Exerc Sci. 2002; 14: 432-441. https://doi.org/10.1123/pes.14.4.432
36. Tudor-Locke C, Bassett DR. How many steps/day are enough? Preliminary pedometer indices for public health. Sports Med. 2004; 34: 1-8. https://doi.org/10.2165/00007256-200434010-00001
37. Crouter SE, Schneider PL, Basset D. Spring-levered versus piezoelectric pedometer accuracy in overweight and obese adults. Med Sci Sports Exerc. 2005; 37: 1673-1679. https://doi.org/10.1249/01.mss.0000181677.36658.a8
38. Hasson R, Haller J, Pober D, Staudenmayer J, Freedson P. Validity of the Omron HJ-112 pedometer during treadmill walking. Med Sci Sports Exerc. 2009; 41: 805-809. https://doi.org/10.1249/MSS.0b013e31818d9fc2
39. Pitchford EA, Yun J. The accuracy of pedometers for adults with Down syndrome. Adapt Phys Activ Q. 2010; 27(4): 321-336. https://doi.org/10.1123/apaq.27.4.321
40. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000; 320: 1240. https://doi.org/10.1136/bmj.320.7244.1240
41. Azulay JP, Mesure S, Amblard B, Blin O, Sangla I, Pouget J. Visual control of locomotion in Parkinson's disease. Brain. 1999; 122(1): 111-120. https://doi.org/10.1093/brain/122.1.111
42. Lewis GN, Byblow WD, Walt SE. Stride length regulation in Parkinson's disease: the use of extrinsic, visual cues. Brain. 2020; 123(Pt 10): 2077-2090. https://doi.org/10.1093/brain/123.10.2077
43. Pongmala C, Suputtitada A, Sriyuthsak M. The study of cueing devices by using visual, auditory and somatosensory stimuli for improving gait in Parkinson patients. Proceedings of Bioinformatics and Biomedical Technology (ICBBT); 2010 Apr 16-18; Chengdu, China. Piscataway Township: IEEE; 2010. p. 185-189. https://doi.org/10.1109/ICBBT.2010.5478983
44. Velik R, Hoffmann U, Zabaleta H, Marti Masso JF, Keller T. The effect of visual cues on the number and duration of freezing episodes in Parkinson's patients. Proceedings of 34th Annual International Conference of the IEEE; 2012 Aug 28 – Sep 1; San Diego, California, USA. Piscataway Township: IEEE; 2012. p. 4656-4659. https://doi.org/10.1109/EMBC.2012.6347005
45. Yoshizawa M, Yoshida Y, Baheux K, Tanaka A, Seki K, Handa Y. Development of virtual reality systems for tests and rehabilitation of patients with hemispatial neglect. Proceedings of 2007 IEEE/ICME International Conference on Complex Medical Engineering; 2007 May 23-27; Beijing, China. Piscataway Township: IEEE; 2007. p. 1313-1316. https://doi.org/10.1109/ICCME.2007.4381956
46. Rochester L, Nieuwboer A, Baker K, Hetherington V, Willems AM, Chavret F, et al. The attentional cost of external rhythmical cues and their impact on gait in Parkinson's disease: effect of cue modality and task complexity. J. Neural Transm. 2007; 114: 1243-1248. https://doi.org/10.1007/s00702-007-0756-y

47. Helmich RC, De Lange FP, Bloem BR, Toni I. Cerebral compensation during motor imagery in Parkinson's disease. Neuropsychologia. 2007; 45(10): 2201-2215. https://doi.org/10.1016/j.neuropsychologia.2007.02.024
48. Camos V, Johnson M, Loaiza V, Portrat S, Souza A, Vergauwe E. What is attentional refreshing in working memory?. Annals of the New York Academy of Sciences. 2018; 1424(1): 19-32. https://doi.org/10.1111/nyas.13616
49. Spaulding SJ, Barber B, Colby M, Cormack B, Mick T, Jenkins ME. Cueing and gait improvement among people with Parkinson's disease: a meta-analysis. Arch. Phys. Med. Rehabil. 2013; 94: 562-570. https://doi.org/10.1016/j.apmr.2012.10.026
50. Costa-Ribeiro A, Maux A, Bosford T, Tenório Y, Marques D, Carneiro M, et al. Dopamine-independent effects of combining transcranial direct current stimulation with cued gait training on cortical excitability and functional mobility in Parkinson's disease. J. Rehabil. Med. 2016; 48: 819-823. https://doi.org/10.2340/16501977-2134
51. Costa-Ribeiro A, Maux A, Bosford T, Aoki Y, Castro R, Baltar A, et al. Transcranial direct current stimulation associated with gait training in Parkinson's disease: a pilot randomized clinical trial. Dev. Neurorehabil. 2017; 20: 121-128. https://doi.org/10.3109/17518423.2015.1131755
52. Chevalier N, Blaye A. Cognitive flexibility in preschoolers: the role of representation activation and maintenance. Developmental Science. 2008; 11(3): 339-353. https://doi.org/10.1111/j.1467-7687.2008.00679.x
53. Carpenter CJ. A meta-analysis of the effectiveness of health belief model variables in predicting behavior. Health Communication. 2010; 25: 661-669. https://doi.org/10.1080/10410236.2010.521906
54. Dumith SC, Gigante DP, Domingues MR, Kohl HW. Physical activity change during adolescence: a systemic review and a pooled analysis. International Journal of Epidemiology. 2011; 40: 685-698. https://doi.org/10.1093/ije/dyq272