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Original Research

The use of new technologies for nutritional education in primary schools: a pilot study

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ABSTRACT

Introduction: The aim of this study was evaluating if the presence of a humanoid robot could improve the efficacy of a game-based, nutritional education intervention.

Study design: This was a controlled, school-based pilot intervention carried out on fourth-grade school children (8–10 years old). A total of 112 children underwent a game-based nutritional educational lesson on the importance of carbohydrates. For one group ($n = 58$), the lesson was carried out by a nutritional educator, the Master of Taste (MT), whereas for another group, ($n = 54$) the Master of Taste was supported by a humanoid robot (MT + NAO). A third group of children ($n = 33$) served as control not receiving any lesson.

Methods: The intervention efficacy was evaluated by questionnaires administered at the beginning and at the end of each intervention. The nutritional knowledge level was evaluated by the cultural-nutritional awareness factor (AF) score.

Results: A total of 290 questionnaires were analyzed. Both MT and MT + NAO interventions significantly increased nutritional knowledge. At the end of the study, children in the MT and MT + NAO group showed similar AF scores, and the AF scores of both intervention groups were significantly higher than the AF score of the control group.

Conclusions: This study showed a significant increase in the nutritional knowledge of children involved in a game-based, single-lesson, educational intervention performed by a figure that has a background in food science. However, the presence of a humanoid robot to support this figure's teaching activity did not result in any significant learning improvement.

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Introduction

Childhood overweight and obesity have seriously risen worldwide in the past decades and represent an alarming socio-economic and public health problem.[1] The prevalence of paediatric overweight and obesity in Europe has been estimated being above 20%,[2] and the number of overweight children has been expected to increase by nearly 1.3 million units per year.[3] In Italy, approximately more than 35% of children are overweight or obese, a worrisome level, higher than the average value of most of the Western countries.[4] Childhood obesity is associated with an increasing risk of chronic diseases, such as cardiovascular diseases, type 2 diabetes, and certain types of cancer, later in life.[5,6] In addition, obese children are more prone to social problems and poor self-esteem, and to become obese adults.[6] These strong consequences stress the need for programmes and policies aimed at preventing paediatric overweight and obesity. However, despite extensive research in this area of primary prevention has been conducted worldwide, some gaps should be covered to identify the most effective models and the best approaches with respect to gender and age of enrolled children.[7]

Schools have been proved to play a pivotal role in the promotion of weight management and healthy lifestyles for school-age children and, thus, to help in the prevention and treatment of childhood obesity.[8] Actually, school interventions based on nutritional education seem to be effective in making children more aware and responsible, and in enhancing their knowledge, skills and attitude.[9] The school environment has been identified as the optimal place to vehicle nutritional recommendation and implement health education activities, allowing to reach a large number of children receiving the same stimuli at the same time and to keep a constant contact with them, favouring the continuity of educational strategies over time.[7,10,11] To be effective, nutritional education should have a secure position in school curricula, to help in the development of healthy eating behaviours and an of adequate nutritional knowledge.[12]

Game-based nutritional learning is an effective approach to enhance children's knowledge, behaviour, and healthy dietary habits.[13] Therefore, playful and creative methodologies should be included into nutritional education programmes for children.[14] Actually, game-based educational tools can represent the best choice for enhancing the efficacy of nutritional education during the learning process.[13] In this sense, new technologies allow the use of more interactive tools to drive information and implement the learning process in an educational context. Among new technologies, information and communication technologies (ICTs) represent a powerful strategy when teaching nutrition. ICT provide a new channel for the promotion of healthy lifestyles and the enhancement of public health[15] and seem to be more effective than traditional printed materials to produce a change in dietary behaviour.[16,17] Among novel ICT teaching strategies, humanoid robots have a special appeal for educational purposes, enhancing interaction among students, teachers, and curricular contents.[18] They can be utilized as tools to deliver abstract theoretical concepts by means of body interaction and physical experience, and to increase children's motivation, engagement, and participation in learning activities.[19,20] Nowadays, robots are applied at all levels of education, not only in health care, where they are being successfully incorporated, but also within the school system.[19] As a matter of fact, Danish schools are starting to use humanoid robots as educational tools and teaching aids from early primary school.[19]

In this framework, the aim of this study was to evaluate if the presence of a humanoid robot could improve the efficacy of a game-based, nutritional education intervention, in order to understand whether the robot–child interactions can support nutritional learning in primary schools. The study was carried out within the Giocampus School Program, a physical and healthy eating educational programme for primary schools (http://www.giocampus.it/) and in the framework of the European project ALIZ-E based on the response of young people to social robots (http://www.aliz-e.org/).

Methods

Design and setting

The present pilot study was a randomized, controlled, school-based intervention with three arms. The efficacy of intervention has been evaluated by a specifically designed questionnaire administered at the beginning and at the end of the intervention, during the 2012–2013 school year. The study was conducted according to the Declaration of Helsinki. The Giocampus School Program intervention has been approved by the Ethical Committee of the University of Parma and then by school boards and teachers.

Intervention

Three different primary schools in the north part of Italy agreed to participate in the research. Two of the three schools, being already involved in a nutritional educational project, the Giocampus project as previously described,[21] were randomly assigned to two different intervention groups. The third school, not involved in any nutrition-oriented educational programme, was assigned to the control intervention.

The two intervention groups were exposed to a nutritional educational lesson (1 h per class), with both a theoretical and a playful phase, conducted in two different ways. The theoretical components in the educational programme were based on well-known nutritional topics. In particular, 'the importance of carbohydrates' theme was chosen among the ones identified by the Giocampus Scientific Committee as the nutritional priorities for the school-aged Italian population.[22,23] The 'learning through playing' approach was reached through the educational game 'GiOCAmpus', as described in a previous study.[21] In the Master of Taste (MT) group, the teaching lessons were realized by the MT, a nutritional education figure created within the framework of the Giocampus project, as previously described.[21] In the MT + NAO group, the MT interacted with a humanoid robot, NAO (Aldebaran Robotics, Paris, France). NAO was specifically set up to be used in teaching activities, explaining the nutritional concepts and actively taking part to the educational game. Thus, verbal and bodily characteristics and behaviour of NAO were developed to make the robot more effective and persuasive in teaching. In Fig. 1, the educational game 'GiOCAmpus' and the humanoid robot NAO are represented.

Participants and inclusion criteria

Students attending the fourth grade of each school (8–10 years old) were invited to join the study. An informed consent containing information about the project was distributed to all the pupils and their parents. Exclusion criteria were: a) lack of written consent to participate from parents; b) lack of verbal consent to participate from students and; 3) absence of the student in at least one of the measurement occasion or intervention day. Of 190 eligible pupils, 145 (response rate 76%) met the inclusion criteria, 33 in the control group (two classes; 17 females and 16 males), 58 in the MT group (three classes; 31 females and 27 males), and 54 in the MT + NAO group (three classes; 27 females and 27 males).

'The importance of carbohydrate' questionnaire

A self-compilable questionnaire was administered by the MT in each class immediately before the beginning and a month after intervention. The MT explained the details about how to fill in the questionnaire and remained in the classroom to answer possible questions or clarification requests. The control group was assessed at the same time and in the same way as the two intervention groups. The questionnaire was specifically designed to evaluate participants' nutritional knowledge on carbohydrates. The questionnaire included 5 questions based on the educational content of the intervention. As shown in Table 1, four out of the five queries consisted of a multiple-choice option, the remaining one was a 9-item true/false question. The cultural-nutritional awareness factor (AF),[21] a score of the nutritional knowledge level, was obtained by adding the score assigned to each response, which could range from 0 to 8.5 points. The score assigned to the multiple-choice options ranged from 0 (wrong answer) to 1 (correct answer), while 0 (wrong answer) to 0.5 (correct answer) points were attributed to each item of the true/false options.

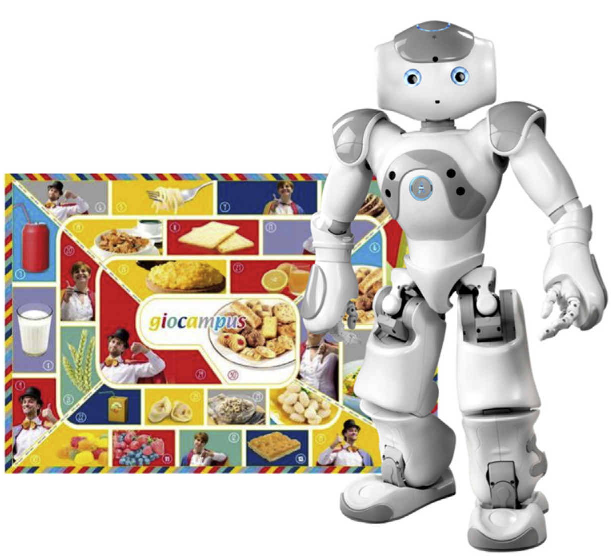

Fig. 1 – The educational game 'GiOCAmpus' and the humanoid robot NAO.

Data analysis

The two main hypotheses targeted through this study were:

a. Confirming that participants receiving an educational intervention will improve their knowledge;
b. Evaluating if participants receiving an educational intervention involving a humanoid robot (as a strategy to increase the focus and the attention span towards the taught messages) will improve their knowledge more than after the basic intervention and more than when no educational intervention is carried out (control group).

The hypotheses were tested by comparing the AF score variations within and among the groups.

In particular, the paired *t*-test was used to compare the mean scores of the AF scores before and after the intervention within each group, to verify the first hypothesis. Moreover, unpaired *t*-test was used to investigate possible differences in the AF scores between genders for each group, both before and after the educational intervention. Comparisons among groups at baseline and at the end of the intervention were carried out to test the second hypothesis, by performing one-way analysis of variance with Tukey's post hoc comparisons. Data analyses were conducted using the Statistical Package for Social Sciences software 23.0 (SPSS®, IBM, Chicago, Illinois, USA) and performed at $P < 0.05$ of significance level.

Results

A total of 290 questionnaires were analysed (108 for the MT + NAO group, 116 for the MT group, and 66 for the control group). AF data for each group are presented in Table 2 as mean ± standard deviation. As revealed by the within-group analysis, children undergoing both the MT and MT + NAO intervention showed progresses in nutritional knowledge. The AF scores significantly increased from 5.9 ± 1.3 to 6.9 ± 1.1 ($P < 0.001$) for the MT + NAO group, and from 6.2 ± 1.7 to 6.9 ± 1.1 ($P = 0.004$) for the MT group. By contrast, AF post-intervention increase did not reach statistical significance, moving from 5.5 ± 1.5 to 6.1 ± 1.4 ($P = 0.063$). No significant differences were observed between genders in each group, both before and after the educational intervention.

With regards to the comparisons among treatments, at baseline, the AF scores were not statistically different among the three groups ($P = 0.092$), whereas significant overall differences were found among groups ($P = 0.002$) at the second assessment. At the end of the study, children in the MT and MT + NAO group showed similar AF scores, but the AF scores of both intervention groups (MT and MT + NAO) were higher than the AF score of the control group ($P = 0.004$ for both comparisons).

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Table 1 – The importance of carbohydrates' questionnaire and scores to determine the cultural-nutritional awareness factor.

Question	Answers	Score
What are carbohydrates?	1. Substances contained in food providing you energy	1 point
	2. Substances contained in food that help strengthen your bones	0 points
	3. Substances that allow the coal to burn	0 points
If you are particularly tired, what can you eat or drink to quickly recover your energy?	1. A tuna and mayonnaise sandwich	0 points
	2. A fruit juice	1 point
	3. Some crisps	0 points
In your opinion, pasta …	1. contains mainly complex carbohydrates	1 point
	2. contains mainly sugars	0 points
	3. doesn't contain any carbohydrates	0 points
Sugars are the main nutrient in:		
Pizza	1. Yes	0 points
	2. No	0.5 points
Oranges	1. Yes	0.5 points
	2. No	0 points
Eggs	1. Yes	0 points
	2. No	0.5 points
Milk	1. Yes	0.5 points
	2. No	0 points
Fruit juices	1. Yes	0.5 points
	2. No	0 points
Ham	1. Yes	0 points
	2. No	0.5 points
Honey	1. Yes	0.5 points
	2. No	0 points
Apples	1. Yes	0.5 points
	2. No	0 points
Beef	1. Yes	0 points
	2. No	0.5 points
Fructose is …	1. The outside part of a fruit	0 points
	2. One of the sugars contained in fruits	1 point
	3. The scientific name of apple worms	0 points

Discussion

The AF score, computed as previously described,[21] increased after both the nutritional intervention groups, with an 11.8% improvement for the MT + NAO group (from 69.7% to 81.5% of the maximum AF score) and 8.1% improvement for the MT group (from 73.3% to 81.4% of the maximum AF score), whereas the increase in the framework of the non-intervention group (control) was only 6.8% (from 64.9% to 71.7% of the maximum AF score). A general knowledge improvement after attending nutritional education at school had been previously described. Warren et al.[24] found a significant 15% nutrition knowledge improvement in primary school-age children (aged 5–7 years) undergoing a multiple-lesson nutrition education intervention. The knowledge improvement reached through approach described in this paper for the two intervention groups was similar to that obtained in a nutritional intervention on the same topic involving an analogous population and imparted by a MT,

Table 2 – Total number of paired questionnaires and values of cultural-nutritional awareness factor (AF) score for each group.

Group	Children (*n*)	Number of questionnaires	AF first assessment	AF second assessment
MT + NAO group	Female	54	6.1 ± 1.3	7.0 ± 1.1
	Male	54	5.7 ± 1.2	6.8 ± 1.0
	Total	108	5.9 ± 1.3^{b}	6.9 ± 1.1^{aA}
MT group	Female	62	6.4 ± 1.6	7.0 ± 1.0
	Male	54	6.1 ± 1.8	6.8 ± 1.2
	Total	116	6.2 ± 1.7^{b}	6.9 ± 1.1^{aA}
Control group	Female	34	5.6 ± 1.4	6.1 ± 1.1
	Male	32	5.4 ± 1.7	6.0 ± 1.7
	Total	66	5.5 ± 1.5	6.1 ± 1.4^{B}

MT, Master of Taste.
Values of AF are shown as mean ± SD. Lower-case letters within a raw indicate a significant difference within each group (paired *t*-test). Upper-case letters within a column indicate significant differences among the three groups without considering the gender (Total; one-way ANOVA with Tukey's post hoc). Significance was accepted for $P < 0.05$.

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where an increase of 11.1% AF score was reported.[21] In the same work, third-to-fifth-grade school children (aged 8–11 years) undergoing multiple nutritional lessons increased significantly their AF scores, bringing to light the effectiveness of a 'learning through playing' nutritional intervention. Game-based education programmes have been outlined as adequate methods to teach nutritional topics. In particular, Viggiano et al.[25] performed a randomized controlled trial in a cohort of students in the south of Italy, in which a board game (named Kaledo) was used to deliver nutrition education to school children. The Kaledo educational game was shown to improve students' nutritional knowledge after an over six-month intervention. All these positive outcomes emphasize the fact that nutritional education should be considered a critical point within the school curricula. Nevertheless, some barriers to teach nutrition in the school environment are present, such as a lack of extra time in teaching new classes, and the fact that nutrition is considered as an non-curricular topic.[26] These barriers should be overcome to make the benefits of nutritional education available to all the students.

Recent studies indicate that school-based nutritional programmes delivered through web-based and ICT tools are more successful to engage students.[27–29] The use of a technology-based educational programme to teach nutritional concepts is very popular, especially because of its capacity to attract child attention and support their learning.[30] As a matter of fact, Turnin et al.[31] reported better nutrition knowledge in primary school children attending nutritional computer-based games than in those in a control group. Similarly, O'Dea[32] studied the general variation in nutritional knowledge and attitudes of an Australian cohort of children participating in the 'Healthy Active Kids' programme, an online literacy programme. This study revealed that nutritional education has an enormous influence on nutritional knowledge, reporting a doubling of total specific knowledge after the intervention. While computer-based approaches have been revealed to be effective for child nutritional knowledge, the role of other technologies used for learning, such as robots,[19,33] is still unclear.

The second hypothesis and main outcome of this study was to assess whether a humanoid robot, NAO, could reinforce a nutritional intervention carried out by the MT. Despite some studies assessing child food choices reporting promising results of robot teaching children about nutrition,[34,35] the presence of NAO in this intervention study did not increase the positive impact of the MT's lessons on nutrition knowledge. Child engagement and motivation towards healthier food choices have been demonstrated to be encouraged through the use of robots;[34,35] however, major attention on the robot does not necessarily result in a higher concentration towards the taught concepts. In our case, the presence of a robot did not reinforce the nutritional knowledge acquired after a human performed teaching lesson.

The gender of the participants was not a factor conditioning children knowledge. As already reported in a study utilizing NAO as a nutritional motivator, 8- to 10-year-old children do not respond differently on the basis of their gender, probably because the majority of them have not fully developed secondary sexual physiognomies and specific social abilities yet.[35]

Some limitations might have reduced the impact of the humanoid robot on child learning, and thus the results of this study. First, the nutritional intervention was carried out in a single educational session, instructing children with a lot of information. Although this short intervention improved children's knowledge significantly, a more effective learning is known to be achieved if the nutritional intervention is conducted on repeated occasions, and a lack of reinforcement obtained through the presence of NAO could not be inferred for such a longer period. A second limitation of this study is the small number of children involved in the nutritional intervention, due to the pilot nature of this study. Child-level randomization among groups, which could have enhanced the power of the study, was not feasible due to institutional, ethical and logistical issues, but this allowed excluding possible influences and interactions among children of different groups.

Finally, some problems linked to the use of this kind of humanoid robot should be considered when designing further longer interventions. The use of this robotic tool is expensive and requires the involvement of specialized computer scientists for IT programming.

In conclusion, this study showed a significant increase in the nutritional knowledge of children involved in a game-based, single-lesson, educational intervention performed by a figure that has a background in food science. However, the presence of a humanoid robot to support this figure's teaching activity did not result in any significant learning improvement. This fact underlined the effectiveness and validity of the MT's 'learning through playing' approach for nutritional education.[21] Despite its prospects, the use of a robotic platform did not enhance the impact of the MT on child knowledge. However, due to the clear ability of NAO to increase the curiosity of the children towards the taught concepts, longer interventions are required to fully understand the potential of NAO in the framework of a nutritional-based school curriculum.

Author statements

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Ethical approval

The Giocampus School Program intervention has been approved by the Ethical Committee of the University of Parma, and then by school boards and teachers.

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Competing interests

The authors have no conflict of interests. NAO robot was provided by the European project ALIZ-E based on the response of young people to social robots (http://www.aliz-e.org/).

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