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"CoVidentary": An online exercise training program to reduce sedentary behaviours in children with type 1 diabetes during the COVID-19 pandemic

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ABSTRACT

Aim: We explored the physical activity (PA) level and the variation in glycaemic control in children with type 1 diabetes (T1D) before and during the lockdown. Then, we proposed an online training program supported by sport-science specialists.

Methods: Parents of children with T1D (<18 years) filled out an online survey. Anthropometric characteristics, PA, play, sport and sedentary time and the medical related outcomes were recorded. An adapted online program "Covidentary" was proposed through full-training (FT) and active breaks (AB) modality.

Results: 280 youth (11.8 ± 3.3 years) were included in the analysis. We reported a decline in sport (-2.1 ± 2.1 h/week) and outdoor-plays (-73.9 ± 93.6 min/day). Moreover, we found an increase in sedentary time (+144.7 ± 147.8 min/day), in mean glycaemic values (+25.4 ± 33.4 mg/dL) and insulin delivery (71.8% of patients). 37% of invited patients attended the training program, 46% took part in AB and 54% in FT. The AB was carried out for 90% of the total duration, while the FT for 31%. Both types of training were perceived as moderate intensity effort.

Conclusion: A decline of participation in sport activities and a subsequent increase of sedentary time influence the management of T1D of children, increasing the risk of acute/long-term complications. Online exercise program may contrast the pandemic's sedentary lifestyle.

Introduction

The SARS-CoV-2 2 (COVID-19) pandemic persists all over the world with health, social, and economic implications that lead governments to enact confinement measures to contain the spread of the virus [1,2]. In Europe, a "second wave" of COVID-19 cases was observed starting from autumn 2020 and mandatory social-isolation, semi-lockdown and "stay at home" orders were reintroduced and imposed upon the population. The Italian Government differentiated restriction measures across the nation (Ministerial Decree of 27th October 2020) and classified Italian regions into red, orange or yellow zones according to epidemiological trends. To reduce public gathering that would heighten the exposure and contagion risk, the Government established the closure of a series of public spaces such as gyms, swimming pools, theatres, cinemas in the whole country. In addition, cafes and restaurants in orange and red zones were closed. Moreover, in these zones schools moved to online delivery, except for children between 0 and 11 years of age.

Children and youth seem to be less vulnerable to COVID-19 symptoms [3]. In particular, children with type 1 diabetes (T1D) had a low prevalence of COVID-19 (11 cases on 15.500 children) [4-6] and

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appeared spared by the complications of COVID-19. Nevertheless, the restrictions disrupted the daily life routine of children and adolescents by limiting interactions and sport and exercise participation [7]. The consequences of these changes are even more serious since active life style contributes to the physical and mental health of children and adolescents, including a more effective immune system [8]. In general "sedentary behavior" is any waking behavior characterized by an energy expenditure $\leq$ 1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture and is associated with negative outcomes at macroscopic and microscopic levels [9-11]. For these reasons the World Health Organization (WHO) recommends at least 60 min/day of moderate to vigorous intensity physical activity (PA) engagement for people aged 5–17 to achieve musculoskeletal and cardiovascular health benefits and psychological wellbeing [12]. During the first phase (WHO declared the global pandemic at 11th March 2020) of the COVID-19 pandemic, PA was restricted for people of all ages and resulted in a reduction of PA levels and time spent playing outdoor for healthy children [7,13,14]. However, it is crucial that children participate in and enjoy PA activities during their leisure time as part of the development of life skills. Preliminary evidences suggest social restrictions needed to reduce the spread of COVID-19 have increased engagement in sedentary behaviour [15], disrupted sleep patterns and increased screen-time exposure [16]. These habits' modifications are detrimental to long-term cardiometabolic and psychological health in the adult population [10,16], and it is likely that such behaviours will evolve into long-term poor health outcomes also in the paediatric age group.

PA has a beneficial main role in the management of T1D across the lifespan, for the improvement of cardiovascular function, positive psychosocial effects and benefits on glycaemic control, [17] such as better general glycemia management and less hyperglycaemic episodes [18,19]. An expected reduction of exercise and an augmentation of sedentary behaviour could, therefore, have deleterious consequences on metabolic control in children and adolescents with T1D [16,17]. To the best of our knowledge, only few studies investigated PA level and glycemia variations during the first phase of COVID-19 Italian lockdown [20,21]. In adults with T1D, Assaloni et al.[22] showed that PA restrictions contributed to reduce PA level and worsened the disease management while, in T1D adolescents with good glycaemic control and HCL system, Tornese et al.[20] found that glycaemic control improved in those who continued PA during the quarantine. With the reintroduction of restrictions during the second wave, we hypothesize a decrease in PA level in paediatric patients with T1D with possible health impairment and difficulty in the disease management.

Considering the above, this study aims to explore the PA level and variation in glycaemic control of Italian children with T1D before and after the introduction of differentiated restrictions based on "colour-coded zones" to contrast COVID-19. Furthermore, it aims to propose an online exercise training program supported by sport-science specialists to counteract a sedentary lifestyle.

Materials and methods

Sample and study design

We conducted an observational study interviewing parents or guardians of children with T1D through an online investigation developed by Sport scientists and Paediatric Diabetologists through "SurveyMonkey software" in Italy (See Supplementary file). The inclusion criteria for children with T1D were age < 18 years, the use of continuous glucose monitoring (CGM) and the ability to understand Italian language. The exclusion criteria were: ongoing COVID-19 infection, being subject to quarantine and cognitive impairments. Parents or guardians were required to fill out a survey about their children composed by multiple aspects referred to two periods: before the second wave of COVID-19 disease and after the introduction of "colour-coded zones" national restrictions. Before starting the survey, all parents or guardians consented to the treatment of anonymised data and agreed to be enrolled in the study for clinical research purposes, epidemiology, study of pathologies, and training, with the aim of improving knowledge, care and prevention [20]. Data were evaluated according to the principles of the Declaration of Helsinki as revised in 2008. The Study Protocol was approved by Institutional Board. The privacy of the collected information was ensured according to the General Data Protection Regulation (EU)/2016/679 (GDPR), and the Legislative Decree n.101/18.

Clinical and socio-demographic outcomes

Children anthropometric characteristics such as body weight (kg) and height (m), the colour of the zones where they lived, attending school in person or online were reported by parents or guardians and all the data were examined by the online survey software (SurveyMonkey inc. 2020, California, Usa). With the same procedure, PA level was investigated including current movement behaviours, changes in children's sport participation and play behaviours prior to the second wave of COVID-19 disease and after the introduction of national restrictions based on "colour-coded zones".

Medical outcomes

Parents or guardians referred children mean glycaemic values (7 days) obtained from CGM in the two periods of the study: two weeks prior and two weeks after the introduction of "colour-coded zones" national restrictions. The self-reported values of the last HbA1c (%) was also recorded. Then, we investigated the self-perceived metabolic compensation (optimal, good or low) before the introduction of restrictions and the alteration provided by the glycemic trend (ameliorated, stable, or worsened with glycemic index rising and/or fluctuating) and changes in insulin delivery (stable, increase or decrease) during the restrictions.

Exercise training intervention through online platform "LAMAJunior"

Further, to support children to be more active, an online platform called "LAMAJunior" was created to deliver the program "Covidentary", which included both exercise and active breaks. LamaJunior was accessible through preassigned login credentials provided by members of the research team. Parents or guardians of the children and adolescents were required to sign the informed consent form prior to accessing the platform. We suggested to children that voluntarily adhered to the project to perform training for eight weeks with a frequency of at least 5 days/week. Sports specialists provided two different approaches to the training. Full-Training (FT) entailed 50-minute-long sessions with a combination of aerobic and resistance exercises adapted to the young age of participants. Four incremental difficulty level routines were created for FT and the exercises were proposed in both a play-based and in a recreational way. Active Breaks (AB) consisted of short bouts of exercises that lasted 3–5 min with a combination of mobility, coordination, balance and yoga movements. The aim of this short training was to cut off prolonged sedentary activities during the daily routine. Sport specialists recommended to perform AB at least 3 times/day for eight weeks. For each training session the online platform recorded the log in details, the duration of the session and the perceived effort from 1 (very easy) to 10 (hard and going to stop) according to the Likert scale [23]. For each participant, the number of accesses was recorded anonymously. The platform was also equipped with a timer to record the duration of each training session, calculated as the difference between the logout and the login times.

Statistical analysis

Quantitative variables were described as mean $\pm$ standard deviation (SD) and qualitative variables as count or percentage as appropriate. The

Shapiro-Wilk test was used to determine the assumption of data normality. Paired *t*-test for continuous variables assessed the comparison between before and after the introduction of "colour-coded zones" restrictions for the whole sample, also according to gender. A p-value of<0.05 was considered statistically significant. All analyses were performed using STATA 13 software.

Results

Exploratory analysis from questionnaire outcomes

A total of 287 parents or guardians with children with T1D answered to the survey. The entries were subject to quality data control in order to evaluate discrepancies in responses, missing data and ineligibility criteria. A total of 280 children and adolescents were included in the analysis. 58·5% of the sample were males; the mean age was 11·8 ± 3·3 years. The mean height was 1·5 ± 0·1 m (z-score 0.1 ± 1.3) and the mean weight was 46·3 ± 17 kg. (z-score −0.1 ± 1.0) BMI mean was 19·5 ± 3·7 Kg/m^2 (z-score. −0.15 ± 1.0). Treatment type was under multiple daily injection (63.8%) and with insulin pump (36.2%). After the introduction of "colour-coded zones" restrictions, 21·7% attended physical education (PE) classes at school in person, 17·5% joined online sessions, while 60·7% did not take part in any type of PE class (data shown in Table 1). We did not find gender differences in every analysed outcome.

As reported in table 2, before and after the introduction of restrictions, we recorded a significant decline in participation in sport activities ($p < 0.001$) and reduction in time spent playing outdoor ($p < 0.001$). Moreover, we reported a significant increase in sedentary time ($p < 0.001$). Finally, a significant increase in mean glycemia values ($p < 0.01$) were also recorded.

Finally, we investigated the variation of perceived metabolic compensation and the insulin delivery. Findings show that after the introduction of "colour-coded zones" restrictions, 57·5% of children with T1D perceived a worsening in metabolic compensation due to increased glycemia mean values and glycaemic variability. 71·8% of children with T1D modified the insulin delivery. In particular, 56% had to modify both the basal and rapid dosage; 30% modified only the rapid dosage; and 15% only the basal insulin dosage.

Exercise training intervention

In table 3, the summary of online training intervention was reported.

Of all invited patients, 106 (37%) participated in the training program. Of these, 46% took part in AB and 54% in FT. We reported that AB were carried out for 90% of the total duration, while the FT only for 31%. Perceived exertion was 2·9 ± 0·6 for AB and 3·4 ± 1·8 for FT. Both AB and FT were perceived as moderate intensity effort.

Table 1
Anthropometrics' and socio-demographical characteristics and participation in PE school classes of the whole sample.

Outcomes	Participants (n = 280)
Colour-coded zones (n)	
- Red	195 (69 6)
- Orange	55 (19 64)
- Yellow	30 (10 7)
Gender (n)	
- Male	164 (58 6)
- Female	116 (41 4)
Age (year)	11 8 ± 3 3
Height (m)	1 5 ± 0 1
Weight (kg)	46 3 ± 17
BMI (Kg/m^2)	19 5 ± 3 7
Hb1Ac (%)	7 2 ± 1 0
PE classes (n/%)	
- In person	61 (21 8)
- Online	49 (17 5)
- None	170 (60 7)

All values are shown mean ± DS (%).

Table 2
PA practice, time spent playing outdoor, sedentary behavior and mean glycemia values of the whole sample before the outbreak of the second wave and after the introduction of colour-coded zones restrictions.

Outcome	Pre	Post	Differences	P-value
Sport activities time (h/week)	3 0 ± 2 6	0 9 ± 1 8*	− 2 1 ± 2·1	< 001
Play outdoor time (min/day)	104 5 ± 104 4	30 5 ± 55 4*	−73 9 ± 93·6	< 001
Sedentary time (min/day)	170 4 ± 141 8	315 1 ± 203 1*	144 7 ± 147 8	< 001
Mean glycemia value (mg/dL)	155 6 ± 32 6	181 0 ± 45 4*	25 4 ± 33 4	< 001

All values are shown mean ± DS. * $p < 0.05$ was statistically significant by paired T-Test.

Table 3
Outcomes of exercise training.

	Active break	Full training
Exercise Login (n)	49	57
Exercise completed Logout (n)	28	18
Exercise completed (%)	57 1	31 6
Age (years)	10 1 ± 3 3	12 3 ± 2 6
Average of Exercise duration (minutes)	3 6 ± 2 5	15 5 ± 12 6

All data was shown mean ± DS

Discussion

A markable decrease in PA levels during the current pandemic of SARS-COV-2 has been described in multiple studies [14,24-26]. To the best of our knowledge, a lack of data about PA reduction and therapy management due to the restrictions during the second wave of COVID-19 pandemic in children and adolescents with T1D still persists. The purpose of our study was to assess the immediate changes in PA level, outdoor play, sedentary behaviours and therapy management in children and adolescents with T1D across Italy. In accordance with Moore et al. and Lopez-Bueno et al., we found a significant lowering in exercise participation and time spent in outdoor playing and a significant increase in time spent engaging in sedentary behaviour [14,27].

Despite the need to limit the spread of SARS-COV-2 continues to be a priority, the introduction of containment measures limits PA practice in children and adolescents and could curb the correct age-development and acquisition of motor skills such as coordination, agility and team-cooperation [28]. In fact, for young people, PA and exercise through movement, music and energy expenditure have numerous benefits in the psychosocial, physiological and developmental realms [29-31]. Longer time spent engaging in sedentary activities are associated with poorer physical and mental health outcomes in the long term. The adoption and maintenance of PA is key for the management of individuals with T1D [32,33]. For people with T1D, PA and exercise has been shown to produce, in addition to general wellbeing, also metabolic improvements in terms of insulin sensitivity and glucose intake [33]. In contrast with Passanisi et al.[21] our results highlighted a worsened management of glycaemic levels in 57·7%, of these, the 18·8% of patients, had an increase of insulin delivery. These findings confirm the crucial role of PA and exercise in glucose control. In fact, both an increased basal and bolus insulin doses were detected. In this period, despite the establishment of telemedicine interventions in Italy [34,35], the patients have less possibilities to interact with clinicians with a possible repercussion on therapeutic decisions, including autonomous changes in basal insulin. In our population, the changes in bolus insulin doses may suggest that the changes in diet also occur. Our data confirms the need of preventative measures during specific periods of restrictions [36]. Such interventions might include the improvement of telemedicine and adapted online exercise routines [37,38] provided by clinicians and sport specialists, supplementary guidance to encourage families to maintain a healthy lifestyle and the implementation of adequate platforms that preserve exercise programs limiting viral transmission.

This study acknowledges its limitations mainly related to voluntary adhesion and data submission. Among other things, the underpinning aim of the project could have given rise to participant bias connected to a greater interest in PA and the benefits of exercise. Moreover, changes in insulin delivery were recorded without specific details of doses, resulting in inaccurate information concerning the insulin requirement. Ultimately, data collection does not allow to ensure the truthfulness of the data and allows people to report subjective points of view. However, we considered this modality useful and prompt thanks to its user-friendly data collection interface combined with the respect for privacy and anonymity. The introduction of “colour-coded zones” restrictions in Italy as in other countries is associated with a decline in sport activities participation, a reduction of time spent playing outdoor and an increase in sedentarism in children and adolescents with T1D. This trend can influence the management of the disease, influencing the risk of acute and long-term complications. Online exercise programs are a promising way to support PA levels and to maintain both health and wellbeing.

“CoVidentary” represents a proposal of an online exercise training program to reduce sedentary behaviours in children with T1D during the COVID-19 pandemic. The outcomes of the exercise sessions designed for this study show that it is possible to reduce sedentary lifestyle, but not to achieve the optimal level of recommended PA according to the PA guidelines for children provided by WHO. Considering the completion outcomes reported above, it can be argued that while a short duration session could be more effective to encourage participation in a self-administrated exercise, the completion of a longer exercise session in line with the minimum level of PA recommended by the guidelines could be successfully achieved only through a supervised program.

In conclusion, a decline in participation in sport activities and PA and a significant increase of sedentary time influence the management of T1D of children, increasing the risk of acute/long-term complications. Online exercise programs may be useful to counteract the sedentary lifestyle associated with the pandemic. A short exercise session that can be repeatedly performed throughout the day, may represent an optimal interventional strategy to maintain both health and wellbeing of youth with T1D.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcte.2021.100261.

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