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Julian V, Ring-Dimitriou S, Wyszynska J, Mazur A, Matłosz P, Frelut ML, Erhardt E, Vlachopapadopoulou E, Forslund A, Boyland E, Weghuber D, Thivel D

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***There is a clinical need to consider the physical activity – sedentary pattern in children with obesity.
Position paper of the European Childhood Obesity Group***

Valérie Julian^{a,b}, Susanne Ring-Dimitriou^c, Justyna Wyszynska^d, Artur Mazur^d, Piotr Matlosz^d, Marie Laure Frelut^e, Eva Erhardt^f, Elpis Vlachopapadopoulou^g, Anders Forslund^h, Emma Boylandⁱ, Daniel Weghuber^b, David Thivel^j

^a Department of Sport Medicine and Functional Explorations, University Teaching Hospital of Clermont-Ferrand, Diet and Musculoskeletal Health Team, Human Nutrition Research Center (CRNH), INRA, University of Clermont Auvergne, Clermont-Ferrand, France

^b Department of Pediatrics, Paracelsus Medical University, Salzburg, Austria

^c Department of Sport Science and Kinesiology, Paris Lodron-University, Salzburg, Austria

^d Medical Faculty, University of Rzeszow, Rzeszow, Poland

^e Pediatric Practice, Albi, France

^f Department of Pediatrics, University of Pécs, Pécs, Hungary

^g Department of Endocrinology, Children's Hospital P. and A. Kyriakou, Athens, Greece

^h Department of Women's and Children's Health, Uppsala University, Uppsala, Sweden

ⁱ Appetite and Obesity Research Group, Department of Psychology, University of Liverpool, Liverpool, UK

^j Laboratory of the Metabolic Adaptations to Exercise under Physiological and Pathological Conditions (AME2P), Clermont Auvergne University, Clermont-Ferrand, France

Short Title: Physical activity-Sedentary patterns of youths with obesity

Corresponding Author: Valérie JULIAN

Department: Department of Sport Medicine and Functional Explorations

Institute/University/Hospital: University Teaching Hospital of Clermont-Ferrand, Diet and Musculoskeletal Health Team, Human Nutrition Research Center (CRNH), INRA, University of Clermont Auvergne, Clermont-Ferrand, France

Street Name & Number: 1, place Lucie Aubrac

City, State, Postal code, Country: 63000 CLERMONT-FERRAND, FRANCE

Tel: +(33) 473 751 888

E-mail: vjulian@chu-clermontferrand.fr

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Abstract:

Introduction: While international prevention guidelines recently advocated, in addition to moderate and vigorous physical activity (MVPA) guidelines, for a minimization of sedentary time (SED), recommendations remain to be developed for youths with obesity.

Methods: A literature search was conducted in PubMed, the Cochrane Library plus the reference lists of selected articles for relevant publications in English, including original papers, systematic reviews, and meta-analyses, with search terms “sedentary behaviors” or “sedentary time” or “screen time” AND “children” or “adolescents” AND “obesity” or “adiposity” or “cardiometabolic risk” or “cardiometabolic disease”. The results were summarized as a narrative review and presented to the scientific board of the European Childhood Obesity Group (ECOG) who then discussed their implication in clinical practice and proposed the position outlined in this paper.

Results: SED and screen times are associated with adiposity and cardiometabolic risks independently of youths’ physical activity level. Besides considering MVPA and SED times as separate variables, comprehensive studies have questioned the impact of different patterns of MVPA and SED levels. Although lower body adiposity and better cardiometabolic health are achieved among those with desirable movement behaviors patterns (i.e., more MVPA/less SED or active/not sedentary), youths with intermediate patterns (i.e., high MVPA/high SED and low MVPA/low SED, or active /sedentary and inactive/not sedentary) have been found to be associated with intermediate risks.

Conclusion: There is a need to decrease SED behaviors irrespective of MVPA and to consider PA-SED patterns in youths with obesity. The European Childhood Obesity Group (ECOG) encourages anti-obesity strategies targeting both physical activity (PA) and SED behaviors to support the shift from long periods of SED time, especially screen time, to daily routines incorporating bouts of PA. Stepwise or sequential approaches to movement behavior counseling might start with targeting SED at first to decrease cardiometabolic risks when implementing MVPA is not yet possible.

Keywords: Sedentary behavior, Pediatric Obesity, Cardiometabolic risk, Physical Activity, Screen time

Introduction

Adhering to nutritional recommendations and engaging in regular physical activity (PA) are the cornerstone of behavioral prevention and treatment of pediatric obesity, related cardiometabolic risks and diseases (e.g. high blood pressure (BP), insulin resistance (IR), type 2 diabetes mellitus, high triglyceride (TG) levels and low high density lipoprotein-cholesterol (HDL-C)) and non-alcoholic fatty liver disease (NAFLD) [1–4]. PA, particularly moderate to vigorous PA (MVPA), is a major determinant of individuals' health, acting on both energy expenditure (EE) and appetite control, reducing adiposity, cardiometabolic risks and fatty liver markers while improving mental health and cognitive functions [4–8]. PA and MVPA are defined as any bodily movement produced by skeletal muscles and leading to a rise in EE above 1.5 and 3 metabolic equivalents task (METs), respectively. Public health guidelines recommend 3 hours of daily PA in children aged 1 to 5 years old and 60 minutes of MVPA in older children and adolescents [9]. Specific health-oriented PA recommendations regarding pediatric obesity management have been detailed for clinical settings, but there are many barriers leading to frequent MVPA intolerance in early cares (e.g. impaired cardiorespiratory fitness and strength related to body weight, restrictions for weight-bearing activities, musculoskeletal pain and discomfort during and after exercising) [10]. Recent evidence has shown that one can be very active (i.e. high MVPA) while also engaging in high amounts of daily sedentary (SED) behaviors (i.e. high SED), SED behaviors being defined as any waking behavior in a sitting, reclining or lying posture (i.e. $EE < 1.5$ METs) [11]. Studies in adults also recently showed that MVPA attenuates without eliminating the risks associated with high SED time [12]. While it remains difficult to implement and sustain MVPA in youths with obesity in clinical practice, targeting SED behaviors could be suggested as an alternative to reduce adiposity and related diseases in children and adolescents. Convinced by the need to consider SED behaviors and the entire PA-SED profile when it comes to the treatment of pediatric obesity, the scientific board of the European Childhood Obesity Group (ECOG) gathered a group of experts to identify the main available scientific evidence on this topic. The group aimed to (i) summarize the current evidence of the role of SED behaviors and specifically patterns of MVPA and SED levels concerning their associations with adiposity and related cardiometabolic risks in youths and to (ii) derive key recommendations for effective and sustainable treatment strategies in clinical practice.

Materials and Methods

A literature search was conducted in PubMed, the Cochrane Library plus the reference lists of selected articles for relevant publications in English, including original papers, systematic reviews, and meta-analyses up to December 23, 2021. Search terms for the literature searches included “sedentary behaviors” or “sedentary time” or “screen time” AND “children” or “adolescents” AND “obesity” or “adiposity” or “cardiometabolic risk” or “cardiometabolic disease”. The results were summarized (VJ, DT) in a narrative review and presented to the coauthors who then discussed their implication in clinical practice and proposed the position outlined in this paper.

Results

The last decade has seen great leaps in device-based measures of SED behaviors in isolation from PA. Epidemiologic studies have highlighted the widespread and excessive SED time, reaching almost 9 hours per day (80% of waking hours) in adolescents of most European and American countries [13,14]. They grow-up in environments saturated with technologies inciting screen time (i.e. time spent in screen behaviors apart from school, such as TV viewing, passive video gaming, computer, portable electronic devices such as smartphones, tablets or laptops using)[15]. Daily SED behaviors have been found to be associated with higher fat mass and cardiometabolic risks in children and adolescents [11,16]. Some studies have reported independent associations between MVPA and SED behaviors, pinpointing SED behaviors as distinct risk behaviors favoring increased adiposity and cardiometabolic diseases in youths [17–20]. Among SED behaviors, recreational screen time [11,16,21] and prolonged uninterrupted SED time bouts (low number and duration of breaks in SED time) [22,23] have shown strong associations with adverse health outcomes. Recent work focusing on comprehensive understanding of the relationships between all key behaviors also demonstrated that high screen time was strongly associated with increased food intake and eating habits that favor weight gain [24]. Diverse mechanisms are likely to explain the associations between SED behaviors and adiposity-related risks i) the low EE of SED time ii) the increase in food intake linked with SED behaviors (particularly screen time), iii) direct specific metabolic impacts of SED time, such as decreases in lipoprotein lipase and glucose transporter activity in skeletal muscle fibers, inducing muscle IR, decreasing fat oxidation and favoring ectopic fat storage and metabolic inflexibility,

and iv) the reduction of peripheral vascular function during SED time [17]. In children and adolescents with obesity, high screen time has been positively associated with body mass index (BMI), high BP, IR, TG, and low HDL-C, independently of PA duration and intensity [25–27]. SED time has been positively associated with fat mass, visceral adipose tissue, IR, low HDL-C, high cumulative cardiometabolic risk score, but also with liver fat content and surrogate markers of NAFLD, independently of MVPA time [4,27–29]].

Moreover, besides considering times spent in MVPA or SED behaviors as individual/separate variables, recent comprehensive studies have questioned the impact of different patterns (or profiles) of MVPA and SED levels (i.e., low MVPA/high SED, high MVPA/high SED, low MVPA/low SED and high MVPA/low SED patterns) (**Fig. 1A**) or different patterns of meeting or not MVPA and SED recommendations (i.e. inactive/sedentary, active /sedentary, inactive/not sedentary and active/not sedentary patterns) [30]. Although lower adiposity and better cardiometabolic and hepatic health are achieved among youths with patterns combining both desirable movement behaviors (i.e. more MVPA/less SED or active/not sedentary patterns), youths with intermediate patterns (i.e. high MVPA/high SED and low MVPA/low SED, or active/sedentary and inactive/not sedentary patterns) have been found to benefit from intermediate risks [30–33]. Different combinations of time spent in SED behaviors, low intensity PA (LPA) and MVPA would thus probably be associated with similar risks [34], highlighting the need to decrease SED behaviors irrespective of MVPA level.

Facing the burden of SED behaviors, international prevention guidelines recently advocated, in addition to MVPA guidelines, for a minimization of SED time, in particular screen time (to be less than 1h per day for children younger than 5 years old, and 2h for older children and adolescents), and a limitation of prolonged SED bouts [9] in order to prevent obesity and other cardiometabolic diseases. However, in youths who are already living with obesity, specific recommendations remain to be developed. Some anti-obesity strategies aiming at breaking up prolonged periods of uninterrupted SED time, replacing it with MVPA (the preferred and more efficient scenario) or with LPA (beneficial but with lower effect estimates) have been proposed [35–37], giving the opportunity to apply an individualized, progressive, and more flexible approach. In clinical practice, this means that youths with obesity should benefit from an individual behavioral diagnosis and support, concomitantly targeting different intensities of PA and SED behaviors, taking into consideration circumstances and abilities. This also means that families, medical and non-medical stakeholders need to recognize SED behaviors to support the shift from long periods of SED time to daily routines incorporating bouts of PA (even low-intensity PA). Stepwise or sequential approaches to movement behavior counseling might start with targeting SED behaviors at first when implementing MVPA at first is not yet possible (**Fig. 1B**). As SED behaviors track even more consistently over time into adolescence and adulthood than PA [38], interventions aiming to decrease SED time are required from the youngest age.

Conclusion

As the only existing international society exclusively dedicated to the study of pediatric obesity, and as part of its objectives to increase awareness and translate research into daily practice, ECOG strongly encourages the following:

- The development of individualized and sustainable interventions targeting SED behaviors (particularly screen time) as a first approach, especially when the implementation of PA programs is difficult.
- Questioning children's PA/SED pattern. Informative and reliable instruments must be developed. While accelerometers provide objective measurements of PA and SED behaviors, their limitations due to economic/logistic burden and time-limited settings remain important. Language specific questionnaires to help practitioners determining all dimensions of SED behaviors (i.e., at school, at home and during transports, separating SED behaviors without and with screen on a timeframe of 7 days including weekdays and weekends) are warranted.
- Further well-designed studies conceptualized to better identify the independent and interactive effects of SED behaviors and PA levels on health outcomes in youth with obesity (from childhood to adolescence).
- The consideration of step by step interventions, first working on a reduction of SED behaviors before properly implementing classical supervised PA programs in youths with obesity.

- The realisation of medico-economic evaluations to assess the cost/benefits of such step by step approaches based on the child PA/SED individual profile.

Statements

Conflict of Interest Statement:

The authors have no conflicts of interest to declare.

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Author Contributions:

Valérie Julian, David Thivel and Daniel Weghuber conceptualized the work, and led search and interpretation of literature and preparation of drafts. Susanne Ring-Dimitriou, Justyna Wyszynska, Artur Mazur, Piotr Matlosz, Marie-Laure Frelut, Eva Erhardt, Elpis Vlachopapadopoulou, Anders Forslund, and Emma Boyland, made substantial contributions to the conception of the work and revised drafts critically for important intellectual content.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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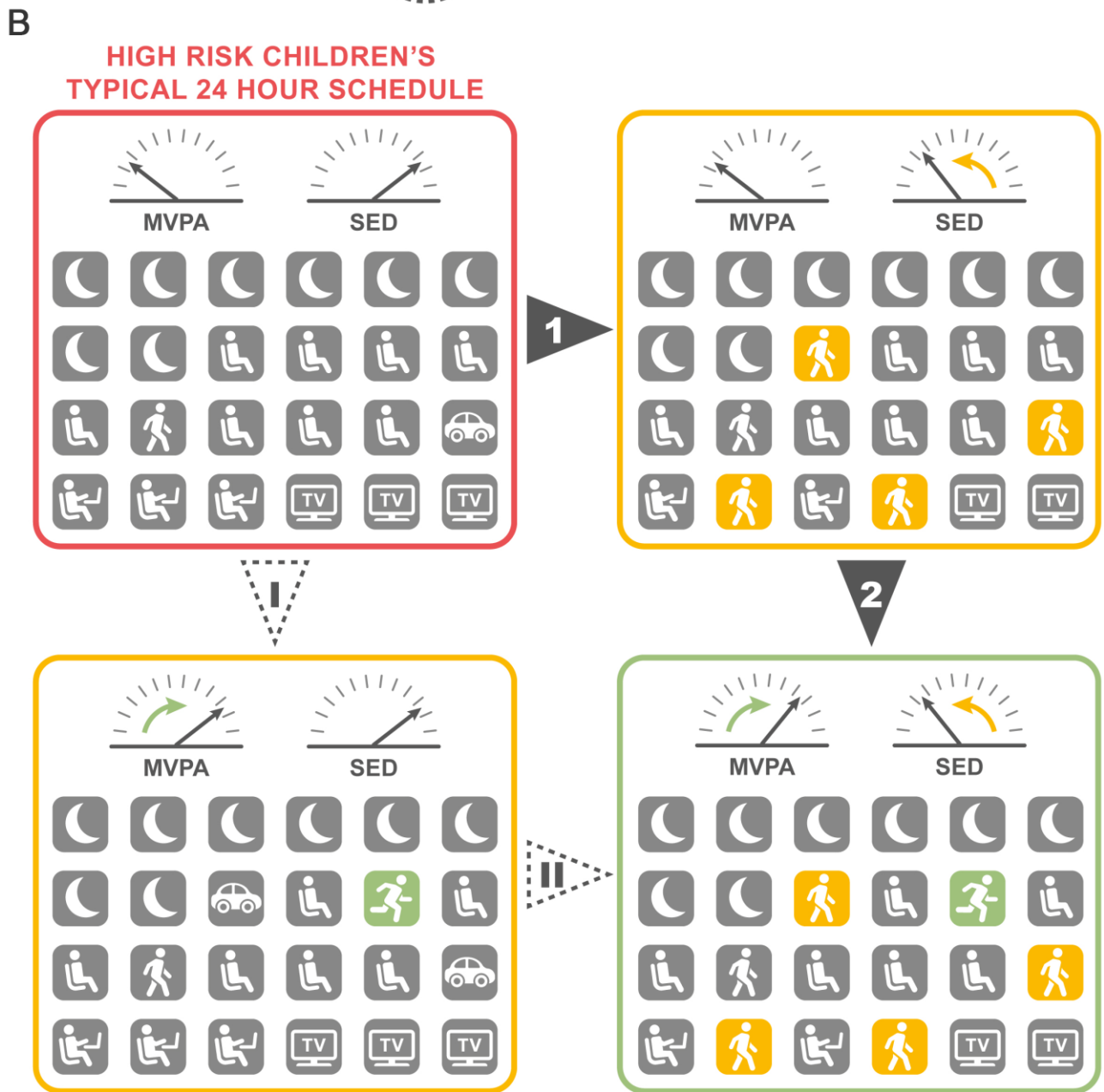
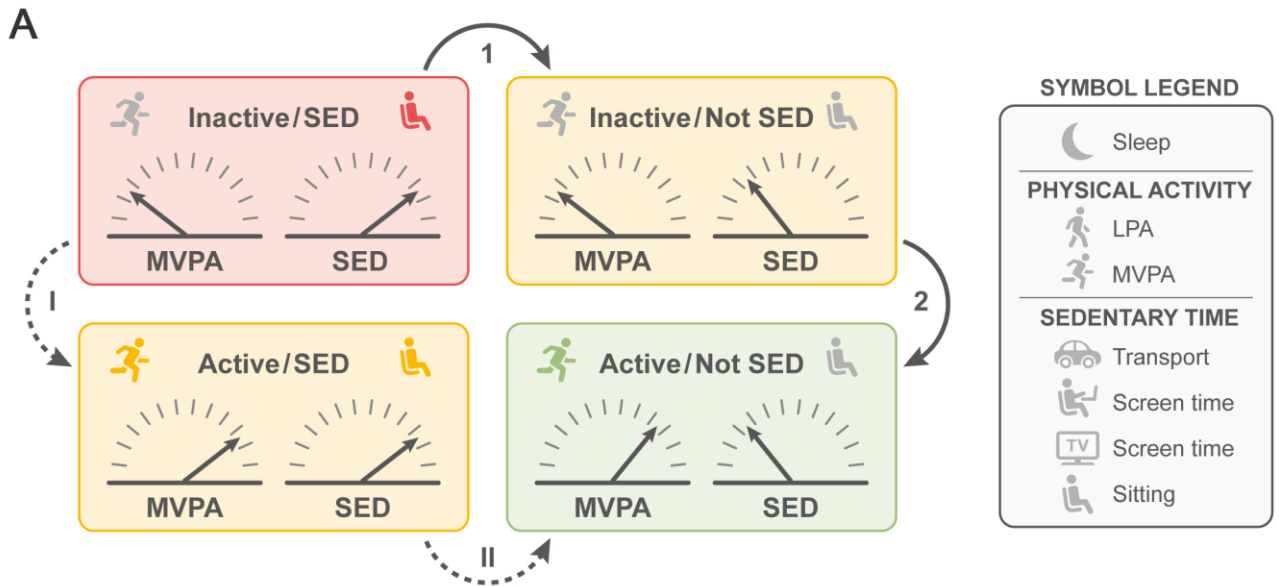
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Figure Legends

Fig. 1A. Combined patterns of moderate to vigorous physical activity (MVPA) and sedentary (SED) times: inactive/sedentary (or low MVPA/high SED), active/sedentary (or high MVPA/high SED), inactive/not sedentary (or low MVPA/low SED) and active/not sedentary (or high MVPA/low SED). While the inactive/sedentary (or low MVPA/high SED) pattern, in red, is associated with the highest risk and the active/not sedentary (or high MVPA/low SED) pattern, in green, is associated with the lower risk, active/sedentary (or high MVPA/high SED) and inactive/not sedentary (low MVPA/low SED) patterns, in yellow, benefit from intermediate cardiometabolic risks.

Fig. 1B. Typical schedule of a high-risk young subject with obesity combining inactivity and sedentariness (low MVPA/high SED profile). Step 1 corresponds to current MVPA recommendations for youths with obesity, aiming at introducing 60 min per day of MVPA for children aged more than 5 years old and adolescents [10]. Step 2 corresponds to 2020 WHO public health guidelines aiming at reducing sedentary (SED) behaviors [9]. Current evidence supports a stepwise approach that might start with targeting SED behaviors (step I, i.e. supporting a shift from long periods of SED time to daily routines incorporating bouts of PA, even low-intensity PA) prior to increasing MVPA (step II), when increasing MVPA is not possible in youths with obesity.

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