Original Article

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Resilience of adolescents in physical activity during the covid-19 pandemic: a preliminary case study in France

Thibaut Derigny [1ABCD], Christophe Schnitzler [2ABCD], Joseph Gandrieau [1ABCD], François Potdevin [1ABCD]

[1]Univ. Lille, Univ. Artois, Univ. Littoral Côte d'Opale, ULR 7369 - URePSSS - Unité de Recherche Pluridisciplinaire Sport Santé Société, F-59000 Lille, France
[2]Laboratory Equipe d'accueil en Sciences Sociales (E3S, UR 1342), Faculté des Sciences du Sport, Université de Strasbourg, Strasbourg, France

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Abstract

Purpose: The objective of this study was to examine how adolescents' physical activity (PA) changed during the COVID-19 crisis according to level of intensity and whether there are typologies of resilience based on individual and environmental characteristics. *Methods*: A longitudinal follow-up study of PA in a representative sample of French adolescents (n=808, 16.32±1.01 years old) was carried out. Two online surveys collecting reported data on amounts of PA were completed the week before and during the first week of the lockdown. Data related to individual and environmental characteristics were collected. A principal component method with qualitative and quantitative data (FAMD) for cluster analysis was performed to identify adolescent's profiles according to their individual, interpersonal and environmental determinants. Two-way repeated measures ANOVA and a Bonferroni Post-Hoc test were performed to detect any significant effects of adolescents' clusters on time and each intensity level of PA. *Results*: Three clusters were identified and characterized by a multifactorial process: active, studious and rural adolescents (37%) reported a significant increase in their MVPA (+707 Mets·week^{-1}, $p<0.05$), inactive, underachieving and rural adolescents (32%) reported a stability in their MVPA (0 Mets·week^{-1}, NS) and urban adolescents (31%) reported a significant decrease of MVPA (-237 Mets·week^{-1}, $p<0.05$). *Conclusion*: This study investigated the multifactorial and temporal complexity of PA resilience according to a socio-ecological anchoring, suggesting that factors of resilience in PA are linked to availability of rural and green environments (environmental determinants), good pedagogical follow up (interpersonal determinant) and high initial involvement in PA (individual determinant).

Keywords: Physical Activity, Adolescents, Resilience, individual and environmental determinants, Lockdown, COVID-19

Author for correspondence: Thibaut Derigny, email: thibaut.derigny@gmail.com

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INTRODUCTION

The health benefits of a physically active lifestyle in adolescence are well documented in the research literature, demonstrating improvements in metabolic [1] and psychosocial behavioral development [2]. However, the overall amount of physical activity (PA) undertaken by adolescents is still insufficient [3] and provokes inactive lifestyle trajectories [4]. The COVID-19 pandemic has amplified the issues that result from sedentary behaviours [5]. After the WHO declared the global COVID-19 pandemic (March 11, 2020), the closure of school, sports facilities and association reception areas resulted in restrictions on liberties and movement in public places [6]. These restrictions have led to claims that PA behaviours have suffered some collateral damage as a result of the (ongoing) crisis [7].

The results of pre-existing international studies on lockdown and social distancing (from 16 March to 11 May 2020 in France) were consensual, showing an overall drop in PA in societies [8-9]. These results varied according to localization [10], gender, age, and the intensity of PA [11]. From a public health perspective, all levels of PA (Light, Moderate and Vigorous PA) are important [12], but moderate and vigorous PA (MVPA) are consistently associated with greater health benefits [13], particularly in the case of the COVID-19 disease [14]. The question of a COVID-19 generation, a cohort diminished in its ability to be active at crucial times in development for sustaining lifelong PA habits, is clearly raised.

One of the most widely used concepts during this crisis is “resilience”. Adapting to issues of health and well-being [15], identity reconstruction [16] or economics [17], resilience has explored many behavioral dimensions [18], but essentially adopting a psychological framework [19]. Used in many disciplines to refer to change, disturbance or adaptation, resilience could be understood as "the ability of a dynamic system to adapt successfully to disturbances that threaten the function, viability or development of the system" [20]. Although it is clearly established that significant life events can have major effects on them [21], identifying factors of PA resilience would help to anticipate changes in behaviours and educate adolescents to maintain sufficient PA during periods of lifestyle disruption. Evidence suggests that resilience as a concept is not limited to a personality trait, considering adaptation as a return to a pre-event level of system stability [22]. Resilience is rather a complex, multifactorial process impacted by internal and external factors with a dynamic of growth [23]. Thus, adoption of a holistic and ecological point of view has been advocated in studying resilience [24]. We might ask whether these three characteristics of resilience concept (complex, multifactorial and dynamical) could be adapted to the particularity of PA resilience.

Ecological theories inspire attempts to define and model resilience [25], envisaging it as multifaceted, multidimensional and dynamic over time. The ecological model of human development [26] has been adapted to PA [27-28] and uses a comprehensive framework to explain overall PA quality, engagement and levels. It proposes that determinants at all levels (individual, interpersonal, environmental, policy and global) are contributors and dynamic to PA engagement. Indeed, PA is impacted as much by sex differences [28] as by environmental constraints and national public policies [29]. However, few studies have looked at the interaction of theses variables to understand the emergence of PA behaviours, especially during a perturbing event such as a pandemic crisis [30]. Our overarching aim was to identify the characteristics of adolescents who are resilient in maintaining PA when moving into a societal lockdown, as a result of a life-changing event.

The purpose of this study was to investigate PA patterns reported by French adolescents during the transition from a normal to a lockdown lifestyle. Throughout the COVID-19 crisis, we aimed to identify psychological profiles of adolescents in order to understand which patterns tended to orient them towards a more or less resilient PA behaviors. We hypothesized that the level of PA resilience depended on a combination of environmental, interpersonal, and individual determinants. We hypothesized that the resilience of participants would be a major constraint on their reported PA, suggesting the emergence of a new concept that future studies could explore.

MATERIAL AND METHODS

Participants

We conducted a longitudinal follow-up with a sample of 808 adolescents (mean age: 16.32±1.01 years old) between March 18 to 30, 2020. Participants were recruited in France through a survey sent by the national union (the SNEP) to all its physical education teachers, who forwarded our questionnaire to their students. We included participants if they were attending secondary school, between 14 and 20 years old, subject to necessary agreements to participate (by PE teacher, family and participant). Participants were excluded when survey were not fully completed (n=79) and were data were incoherent (n=42) (e.g., reported participation being more than 7 days a week or more than 10.000 minutes per week). Outliers were excluded using the statistical method of Grubb Test (n=43). This study was authorized by the Ethics Committee of the University of Lille in France under the number 2020-418-S82 and the CNIL (*Conseil National de l'Informatique et des Libertés*) under the number 2020-037.

Measures

We used the International Physical Activity Questionnaire-Short Version (IPAQ-SV) [31] to collect retrospective data about the PA activities reported by participants during a normal week before lockdown and PA during the first week of lockdown. The IPAQ-SV measures specific types of activity undertaken during the previous seven days to structure PA into different intensities. Following the French national policies on classification of PA profiles [32], we classified the adolescents into three initial profiles of PA levels undertaken before lockdown: inactive (<600 Mets·week^{-1}), little active (600 to 3.000 Mets·week^{-1}) and active (>3.000 Mets·weeks^{-1}).

Individual, interpersonal and environmental factors represent the three dimensions that we collected data on by questionnaire, according to the ecological modelling of PA [27]. The last two determinants (regional and global) correspond to the context of the COVID-19 pandemic with the lockdown and social distancing measures, and the re-organization of the educational system in France. As shown Table 2, these three ecological determinants were analysed through interactions with sex differences and the initial levels of PA reported (individual determinants), the pedagogical monitoring (physical education homework at the residence) and the sport social support (interpersonal determinants) and socio-economic status families, the localization (urban/rural) and type of residence (house/flat), the presence of garden and sports equipment at home (environmental determinants).

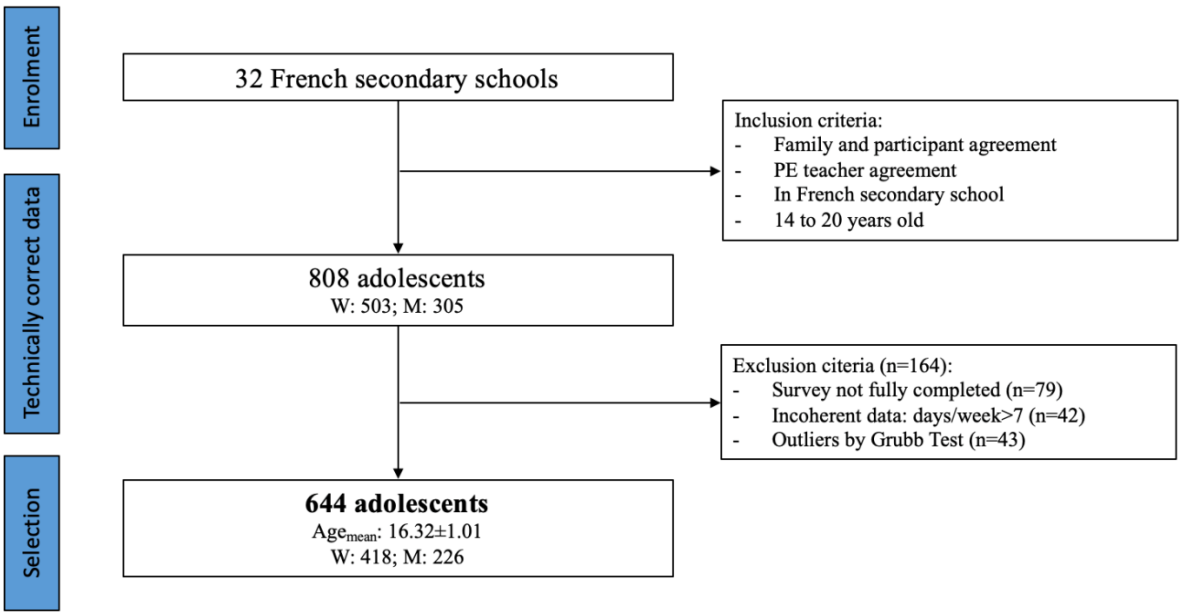


Figure 1. Flowchart of participants selection.

Statistical analysis

An exploratory cluster analysis was used to pool adolescents into homogeneous clusters representing similar characteristics related to individuals, interpersonal characteristics and environments. Cluster analysis is a convenient method for organizing variables into groups. Here we used it to identify groups of individual students that were similar to each other but different from individuals in other groups in terms of reported PA characteristics. The clustering variables in this study were presented in Table 2. We used a specific principal component method to analyze a data set containing both quantitative and qualitative variables [33]: a Factor Analysis of Mixed Data (FAMD). FAMD could identified clusters of participants based on ecological characteristics whose correlates were considered relevant and differentiating for the purposes of this study. Graphical analysis [34] and Schwarz Bayesian information criteria (BIC) [35] were used to determine the optimal number of clusters for our participant sample. Data reduction was considered robust when two dimensions accumulated an explanation greater than 50% of the variance [36]. Descriptive statistics were performed to represent the characteristics of the final clusters. Each cluster has been labelled according to the statistically significant variables by Chi-Square test and as the modality/class is higher than 50% (Mod/Cla corresponds to the percentage of cluster members with the correspondent characteristics). A Classification and Regression Tree (CART) model were used to predict the adolescent clusters according to individuals, interindividual and environmental variables.

To measure the differentiated evolution of PA for each cluster between the periods before and during lockdown, paired samples Wilcoxon tests were conducted. We followed the recommendations of Cohen (1988) to consider the Cohen's d as a small effect when >0.2, medium when >0.5, and large when >0.8 [37]. A two-way ANOVA for repeated measures (cluster x time; repeated measures variable: participants) was performed to detect any significant single and interaction effects on LPA (Light PA), MVPA and LMVPA (Light, Moderate and Vigorous PA). Analysis of the sphericity assumption between levels of repeated measures variables was undertaken by Mauchley's test to check whether the variances of the differences between all combinations of the variables were equal. If not, the Greenhouse-Geisser (GGe) epsilon correction was used. A Bonferroni test was used for post hoc analyses of difference tests. Partial Eta squared values (η_p^2) were used to examine the effect sizes with a 95% confidence interval, considering a small effect size when η_p^2>0.01, medium when η_p^2>0.06, and large when η_p^2>0.14 [37].

All quantitative variables (each reported intensity of PA) and residuals from exploratory models were tested for normality, homoscedasticity and interdependence of the residuals (Shapiro-Wilk; Jarque Bera; Bptest; Durbin Watson test). Non-normality distribution of theses quantitative variables leading us to perform non-parametric statistical analyses. Outliers were excluded by use of Grubb Tests. The free R software (version 1.2.50.33) with different packages was used for the statistical analyses (FactoMineR, tidyverse, rstatix, rpart, car, psych, pwr, pdlyr, outliers). Statistical level of confidence was set at p<0.05.

RESULTS

Cluster characteristics

In total data from 644 adolescents (418 girls, 226 boys) were included in the analyses, whilst data from 168 participants was deleted according to our exclusion criteria. The cluster analysis identified three meaningful clusters based on graphical analysis and on Schwarz's BIC and allowed us to study the sample with a satisfactory heterogeneity between the groups. The dimensions 1 and 2 from FAMD analysis explained 57% of the variance (Table 1). Dimension 1 was correlated with variables linked LPA (R^2=0.79, p<0.05), PA initial profile (R^2=3.02^{e-01}, p<0.05) and out of school practice (R^2=8.02^{e-02}, p<0.05). Dimension 2 was correlated with variables linked MVPA (R^2=0.95, p<0.05), sports equipment at home (R^2=2.83^{e-02}, p<0.05), housing (R^2=2.67^{e-02}, p<0.05), localization (R^2=2.53^{e-02}, p<0.05), garden (R^2=2.25^{e-02}, p<0.05) and pedagogical monitoring (R^2=2.04^{e-02}, p<0.05). Clusters 1, 2 and 3, were composed of 179 (28%), 291 (45%) and 174 (27%) participants respectively. The three clusters and their statistically significant outcome effects in the clustering variables are presented in Table 2.

Table 1. Eigenvalues with % of variance for each dimension, related to FAMD analysis

Eigenvalues	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
Variance	1.48	1.37	1.01	0.93	0.21
% of variance explained	29.61	27.40	20.15	18.64	4.20
Cumulative % of variance explained	29.61	57.01	77.16	95.80	100.00

Table 2. Presentation of clusters according to the significant representation of socio-ecological variables among participants

Socio-ecological determinants^		Overall adolescents N (%)	Cluster 1 Cla/Mod - Mod/Cla (%)	Cluster 2 Cla/Mod - Mod/Cla (%)	Cluster 3 Cla/Mod - Mod/Cla (%)
Cluster size		644 (G:503/B:305)	179 (87/92) 27.8%	291 (205/86) 45.2%	174 (126/48) 27%
Individual					
Gender*	p=4.76^{e-07}				
Girls		418 (65)	NS	49 – 70.4	30.2 – 72.4
Boys		226 (35)	NS	NS	NS
PA initial profile*	p=6.44^{e-70}				
Active		236 (36.7)	69.5 – 91.6	NS	NS
Little active		338 (52.5)	NS	63.3 – 73.5	32.3 – 62.4
Inactive		70 (10.8)	NS	NS	NS
Interpersonal					
Pedagogical monitoring*	p=1.31^{e-05}				
No continuity		138 (21.4)	NS	NS	NS
Continuity not executed		262 (40.7)	NS	NS	NS
Continuity executed		244 (37.9)	37.7 – 51.4	NS	NS
Sport social support*	p=2^{e-02}				
Yes		455 (70.7)	NS	NS	24 – 62.6
No		189 (29.3)	NS	NS	NS
Out of school PA practice*	p=2.7^{e-24}				
Yes		425 (66)	40.7 – 96.7	38.8 – 56.7	39.7 – 50
No		219 (44)	NS	NS	NS
Environmental					
Parents' profession*	p=1.63^{e-03}				
LSES		337 (52.3)	NS	NS	32.1 – 62.1
HSES		397 (47.7)	33.2 – 57	NS	NS
Localisation*	p=4.74^{e-36}				
Urban		319 (49.5)	NS	NS	48.9 – 89.7
Rural		325 (50.5)	NS	63.4 – 70.8	NS
Housing*	p=1.87^{e-94}				
House		422 (65.5)	32.7 – 77.1	66.1 – 95.9	NS
Flat		222 (34.5)	NS	NS	76.1 – 97.1
Garden*	p=1.36^{e-82}				
Yes		440 (68.3)	32.3 – 79.3	63.4 – 95.9	NS
No		204 (31.7)	NS	NS	76 – 89.1
Sports equipment at home*	p=1.52^{e-07}				
Yes		457 (71)	32.6 – 83.2	NS	21.4 – 56.3
No		187 (29)	NS	NS	NS

^Chi-square test. *p<0.05; NS: Mod/Cla<50%; LSES: Low Socio-Economic Status; HSES: High Socio-Economic Status; Mod/cla indicates the share (%) of all participants present in this cluster; Cla/mod indicates the share (%) of all individuals with this modality in this cluster.

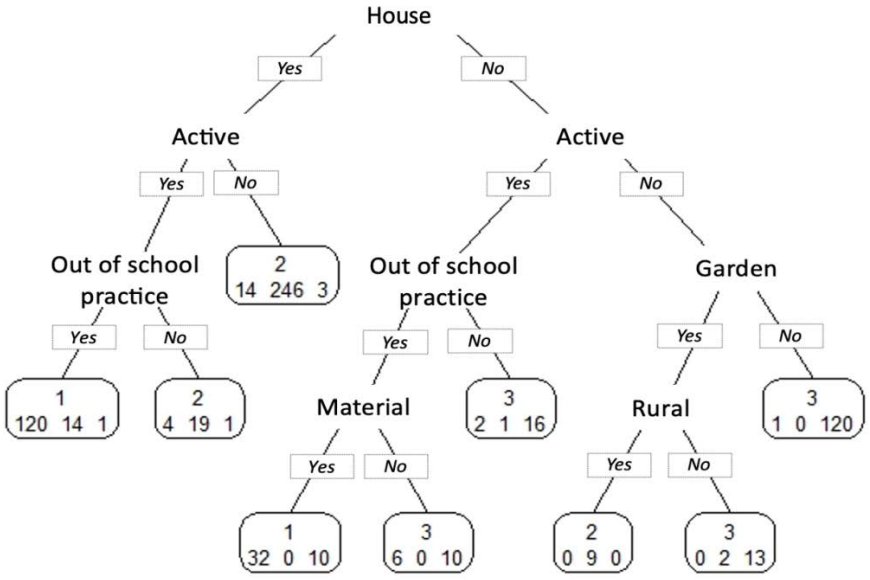
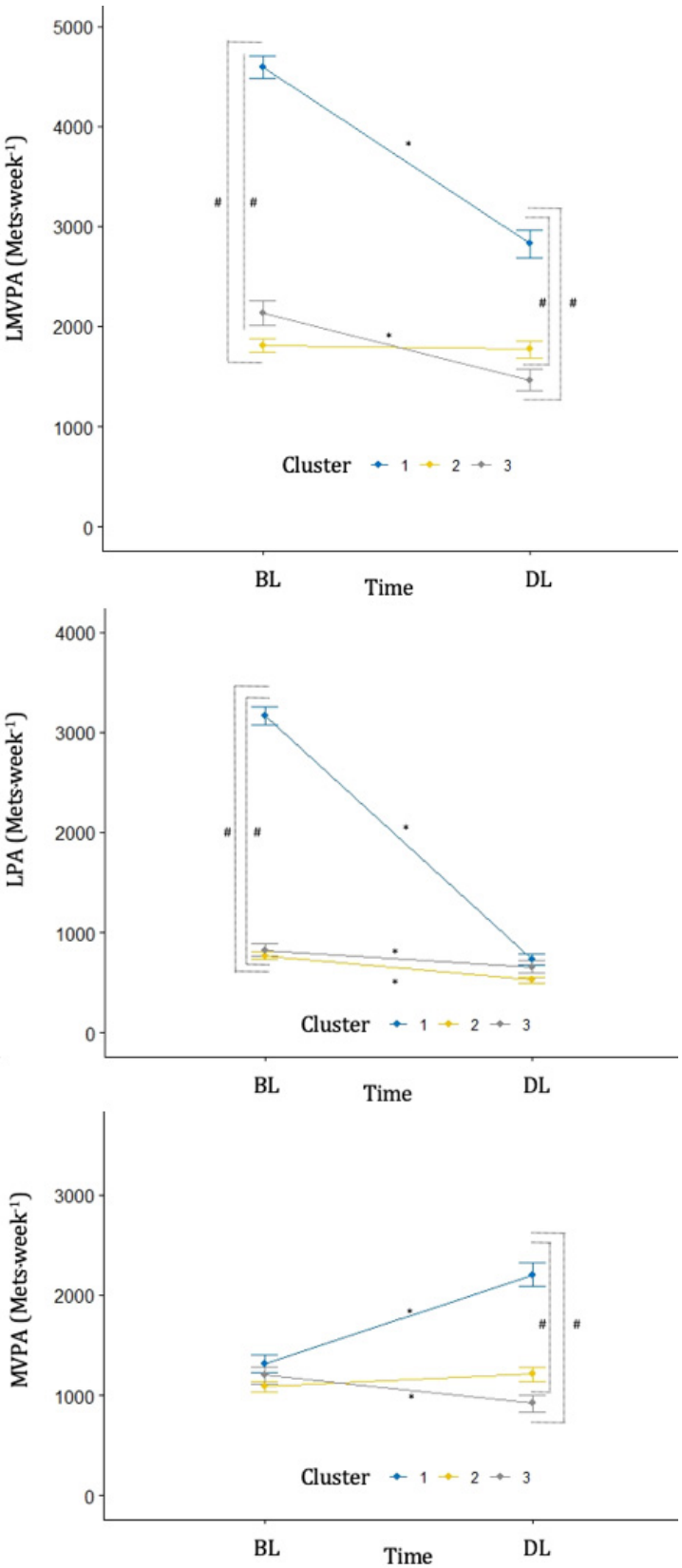


Figure 2. Decision tree of socio-ecological variables orienting to clusters

Table 3. Evolution of the PA according to the cluster (median values)

Cluster	LMVPA			LPA			MVPA		
	BL	DL	Δ	BL	DL	Δ	BL	DL	Δ
C1	4204 [a;b] [Q1:3558; Q3:5386]	2400 [a;b] [Q1:1348; Q3: 3972]	-1599* [Q1: -2944; Q3: 0] $p<2.2^{e-16}$ d=0.95,large pwr=1	2880 [a;b] [Q1:2320; Q3: 3840]	480 [Q1:240; Q3: 930]	-2480* [Q1: -3240; Q3: -1680] $p<2.2^{e-16}$ d=1.75,large pwr=1	1020 [a] [Q1: 570; Q3:1698]	1980 [a;b] [Q1: 960; Q3:3360]	**+707* [Q1: -206; Q3: 2001]** $p<2.2^{e-16}$ d=0.61, medium pwr=1
C2	1700 [Q1: 906; Q3: 2498]	1476 [Q1: 704; Q3: 2236]	0 [Q1: -505; Q3: 160] NS d=0.04,small pwr=0.1	720 [Q1:160; Q3: 1200]	360 [Q1:160; Q3:720]	-160* [Q1: -720; Q3: 240] $p<2.2^{e-16}$ d=1.75,large pwr=1	810 [Q1: 444; Q3:1483]	993 [Q1: 302; Q3:1680]	**0 [Q1: -560; Q3: 804]** NS d=0.12, small pwr=0.5
C3	1776 [Q1: 960; Q3: 2805]	896 [Q1: 443; Q3: 2059]	-271* [Q1: -1369; Q3: 36] $p<2.2^{e-16}$ d=0.45,small pwr=0.1	620 [Q1: 20; Q3: 1280]	410 [Q1:165; Q3: 840]	-48* [Q1: -710; Q3: 270] $p=0.02$ d=0.16,small pwr=0.57	1016 [Q1: 444; Q3:1576]	488 [Q1: 41; Q3:1469]	**-237* [Q1: -1001; Q3: 265]** $p<0.001$ d=0.28, small pwr=0.96
CE	$p<2.2^{e-16}$ $\eta_p^2=0.25$, large; pwr=1			$p<2.2^{e-16}$ $\eta_p^2=0.06$, medium, pwr=1			$p<2.2^{e-16}$ $\eta_p^2=0.33$, large; pwr=1		
TE	$p<2.2^{e-16}$ $\eta_p^2=0.07$, medium; pwr=1			$p<2.2^{e-16}$ $\eta_p^2=0.01$, small; pwr=1			$p<2.2^{e-16}$ $\eta_p^2=0.25$, large; pwr=1		
CTE	$p<2.2^{e-16}$ $\eta_p^2=0.05$, small; pwr=1			$p<2.2^{e-16}$ $\eta_p^2=0.04$, small; pwr=1			$p<2.2^{e-16}$ $\eta_p^2=0.28$, large; pwr=1		

The median score is given in Mets·week^{-1} and the interquartile ranges Q1 and Q3; Bold: main results with MVPA delta (level of resilience for PA intensity recommended by WHO); *Significantly temporal difference (before to lockdown); [a] Significantly difference between C1 and C2; [b] Significantly difference between C1 and C3; Δ: Time before to during lockdown; BL: Before Lockdown; DL; During Lockdown; CE: Cluster effect; TE: Time effect; CTE: Cluster* Time effect; NS: Non-Significant; LMVPA: Light, moderate, vigorous physical activity; LPA: Light physical activity; MVPA: Moderate and vigorous physical activity.



* Significant differences between before lockdown (BL) and during lockdown (DL) for fixed cluster; # Significant differences between each cluster (C1 vs C2 vs C3) for the same time.

Figure 3. Evolution of physical activity for each cluster according to the transition by normal to lockdown life events.

Based on the scores on the clustering variables (Cla/Mod and Mod/Cla), the first profile was labelled to describe participants who may be considered as *active, studious and rural adolescents*, the second profile was labelled *inactive, underachieving and rural adolescents* and the third profile was labelled *urban adolescents*. These labels are based on the scores on the individual, interpersonal and environment ecological variables. All profiles differ significantly (p<0.05) with regard to all the socio-ecological variables (see Table 2).

The decision tree (Figure 2) showed that the first three factors which determined the participants' membership of a cluster are consecutively: their housing (environment), their initial profile of PA (individual) and their 'out of school' PA behaviours (inter-personal). In each case, the number in the first line within each node represents the dominant cluster and the numbers in the second line are the details of participants moving to a particular cluster (e.g. 14 246 3 for the cell 'active' -> 'no' means that 14 participants went to cluster 1, 246 to cluster 2 and 3 to cluster 3).

Evolution of PA according to clusters and the implementation of lockdown

Based on the two-way repeated measures ANOVAs, our results revealed significant effects of cluster and time (before and during lockdown) on intensities of PA undertaken (presented in Table 3). More precisely, the ANOVA outcome of time-cluster interactions showed significant effects for LMVPA ($F_{(2,641)}$=77.8, p<0.05, η_p^2=0.05), LPA ($F_{(2,641)}$=282, p<0.05, η_p^2=0.28) and MVPA ($F_{(2,641)}$=45.9, p<0.05, η_p^2=0.04).

Active, studious and rural adolescents (N=179; 27.8%) reported a significant decrease of LMVPA (-1599 Mets·week^{-1}, p<0.05, d=0.95, large) and LPA (-2480 Mets·week^{-1} p<0.05, d=1.75, large), but a significant increase in MVPA (+707 Mets·week^{-1} p<.05, d=.61, medium). *Inactive, underachieving and rural adolescents* (N=291; 45.2%) reported stability in the evolution of their LMVPA (0 Mets·week^{-1} NS, d=0.04, small) and MVPA (0 Mets·week^{-1} NS, d=0.12, small), but a significant decrease of LPA (-160 Mets·week^{-1} p<0.05, d=1.75, large). *Urban adolescents* (N=174; 27%) reported a significant decrease of LMVPA (+271 Mets·week^{-1} p<0.05, d=.45, small), LPA (-48 Mets·week^{-1} p<0.05, d=0.16, small) and MVPA (-237 Mets·week^{-1}, p<0.05, d=0.28, small).

Post-hoc results showed differences between clusters within the same time periods. We were able to identify that participants in cluster 1 had significantly more PA than cluster 2 before lockdown for each PA intensity and during lockdown for LMVPA and MVPA (p<0.05). We also observed that the same participants in Cluster 1 were significantly more active than those in Cluster 3 *before lockdown* for both LMVPA and LPA, as well as *during lockdown* for LMVPA and MVPA. The post-hoc tests did not reveal any significant differences between clusters 2 and 3 for the same time frames. In contrast, the post-hoc results showed significant interactions between time and clusters on reported PA intensities (Figure 3).

DISCUSSION

The aim of this study was to investigate the complex and holistic concept of resilience in PA in response to the perturbing effect of a life event (here the societal lockdown in the 2019-2020 COVID-19 crisis) and to identify groups of adolescents reporting impacts on their PA characteristics. Our data suggest that the ecological characteristics (individual, interpersonal and environmental) of the sample of adolescents impacted their PA resilience behaviours. More specifically, rural adolescents seemed to report greater resilience in PA behaviours than urban adolescents in maintaining levels of PA intensity during the initial impact of the state lockdown.

This study shows a temporal impact of lifestyle disruptions on the evolution of PA, since all the profiles reported showed some significant changes in PA characteristics when moving from a normal to a lockdown lifestyle (with the exception of cluster 2 in MVPA). These results corroborated findings of pre-existing studies on the evolution of PA during lockdown for adolescents [32] and on other population [8] confirming the sensitivity of adolescent behaviours to periodic perturbations by such life events [4;21]. All adolescents (C1, C2 and C3) had decreases in their overall PA (LMVPA) but the specific changes in the LPA and MVPA characteristics led us to consider the shift to a new understanding of PA behaviors appropriate to the socio-ecological characteristics of adolescents. Our study of PA during lockdown was the first geo-spatial analysis to confirm that lockdown led to a

reduction in light-intensity travel through the cessation of active locomotory transport, such as cycling and walking [10]. These results show the impact of a transition from coincidental PA, involved in active travel in daily life, without specific leisure or health purposes (LPA), to the need for more voluntary engagement in organized PA programs (MVPA) [38].

Results also revealed that each adolescent profile had its own evolution of PA types during this period of lifestyle disruption. The initial patterns of LMVPA in cluster 1 were significantly different from those of clusters 2 and 3. But this gap tended to reduce when moving into lockdown, although the differences remained statistically significant. This trend became more pronounced for the LPA values where the initial significant differences were no longer statistically significant during lockdown. This finding contrasted to the MVPA values which went from homogeneity between the three groups to heterogeneity with a statistically significant difference between cluster 1 with clusters 2 and 3. These results are aligned with findings from PA studies on psychological aspects, showing sex differences in adaptation to lockdown amongst adolescents [28]. Our results complement data from studies of PA engagement, showing a differentiation of motives to engage in PA and questioning a broader temporality, with persistence observed rather than immediate engagement.

The adolescents in cluster 1 seemed to be the most sensitive to these changes. This result suggests that they perceived the lockdown as an opportunity to become more physically active during leisure time, which translated into higher MVPA, an intensity increase that may be beneficial for their health according to WHO guidelines [39]. In contrast, the significant decrease in the MVPA of cluster 3 can be interpreted as the removal of the compulsory VPA that these adolescents could not continue to in, for example, in supervised leisure activities such as sports clubs or school physical education lessons, yet necessary in engaging in health-promoting PA [40]. As a dynamic process that can be understood as subjective and sensitive [20], our methodology would benefit from a follow-up qualitative analysis of resilient and non-resilient PA behaviours in order to explore and verify the perceptions of protective and inhibitory factors of adolescents' PA [41].

Although resilience has been conceptualized through a psychological approach [19], it is increasingly being studied and understood from a socio-ecological perspective [20]. In this sense, resilience would appear to be a multifactorial process [24] linked to our clusters determined statistically by an interaction of individual, interpersonal and environmental variables. The results of the present study, notably the decision tree (Figure 1), revealed some interesting insights into the complex interactions between these multi-level variables in alterations to resilience of PA behaviours. In particular, the data emphasized the prominence of environmental constraints on PA resilience. Specifically, the geographical location of an adolescent's home was a primary environmental constraint on whether they showed resilience in their current PA behaviours or not. Rurally located adolescents (clusters 1 and 2) benefited from increases or maintenance in their MVPA when moving into lockdown, whereas urban adolescents reported a decrease in this PA intensity.

The concept of resilience may also be situated within a dialectic between homeostasis and growth opportunity [42]. Considering that participants in clusters 1 and 2 reported more resilience than those in cluster 3, the different evolution of their MVPA invited some interesting questions on this issue. Our results showed a significant increase in PA in cluster 1 (+707 Mets·week^{-1}; p<0.05, d=0.61, medium) while participants in cluster 2 maintained their initial MVPA levels (0 Mets·week^{-1}; p=0.15; d=0.12, Non-significant). These differences among clusters may be explained by the impact of individual (initial PA profile) and interpersonal (out of school practice or not) variables in the orientation towards cluster 1 and/or 2. Thus, resilience does not seem to emerge from the presence of mere individual characteristics, but rather, may be shaped by an interaction of personal, interpersonal and environmental variables. This finding opens up the possibility for a better understanding of the relationship between an individual with their PA behaviours. This contribution to the continued understanding of the concept of resilience in PA provides some new insights on the relationships that individuals have with their lifestyles, particularly as these are continually shaped by the environment, with a clear experiential, individual dynamic process.

The strengths of this study consisted in the use of a questionnaire with a high degree of reliability [31] to gain data from a large sample of French adolescents (n=808) leading to sufficient statistical power (β>0.8). The methodology could also have benefitted from the use of complementary objective measures, such as accelerometers, although this addition may have constituted an intrusion

into the lives of some participants [43]. Methodologically, a limitation appears in the non-exhaustiveness of the socio-ecological variables measured, although again it is important to balance the intrusion into participants' lives by implementing such large-scale measurement instruments. However, the variables used to create the clusters did seem to be representative of the adolescents' lifestyles during the initial lockdown period [32]. These initial results highlighted three characteristics of the concept of resilience in PA (opportunity for growth, ecological anchoring and temporal dynamics). Further studies are needed to model the concept of resilience in PA so that practitioners could adapt their interventions to the profiles of specific groups such as elderly individuals, adolescents, or people with disabilities, for example.

CONCLUSION

The aim of this study was to investigate the complex and holistic concept of resilience in PA through the effects of a societal lockdown, to identify how different groups of adolescents may have been impacted in terms of their PA. This study showed that ecological characteristics (individual, interpersonal and environmental) of adolescents impacted their PA resilience behaviours, with rurally located adolescents reported more resilient PA behaviours than urban adolescents. Thus, the concept of resilience should not be studied only from an individual psychological perspective. Since PA resilience is a complex and holistic model, future interventions to promote PA during a period of lifestyle disruption should be oriented towards addressing the socio-ecological profiles of adolescents, rather than focusing on global proposals to increase the probability of persistence in PA for all groups. More specifically, the increase in leisure time during lockdown seems to be have been perceived as a growth opportunity for PA in some adolescents, depending on the influences of a set of interacting factors (internal and external). This new perception leads to the promotion of targeted and ambitious strategies on the part of healthcare stakeholders, which is not limited to the maintenance of LMVPA, but targets adolescent MVPA for quality interventions. Further studies should examine the concept of resilience in terms of an objective PA measurement methodology or look more closely at the dynamic aspect of resilience [20], which could be better considered as multidisciplinary, multidimensional, multi-personal, dynamic and temporally. The emergence of resilient behaviours for maintaining PA levels is primarily determined by the environmental variables of the socio-ecological model of PA engagement. PA policy makers, educators and practitioners could identify profiles of more or less resilient adolescents in order to tailor their interventions for future disruptions such as lockdowns or other life-changing events (e.g., major illnesses and injuries).

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