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THE *DESTRESS FOR SUCCESS PROGRAM*: EFFECTS OF A STRESS EDUCATION PROGRAM ON CORTISOL LEVELS AND DEPRESSIVE SYMPTOMATOLOGY IN ADOLESCENTS MAKING THE TRANSITION TO HIGH SCHOOL

S. J. LUPIEN,[a,b]* I. OUELLET-MORIN,[a,c] L. TRÉPANIER,[a,d] R. P. JUSTER,[a,e] M. F. MARIN,[a,f] N. FRANCOIS,[a] S. SINDI,[a,e] N. WAN,[a] H. FINDLAY,[a] N. DURAND,[a] L. COOPER,[a] T. SCHRAMEK,[a] J. ANDREWS,[a,e] V. CORBO,[a,g] K. DEDOVIC,[a,h] B. LAI[a,i] AND P. PLUSQUELLEC[a,j]

[a] *Centre for Studies on Human Stress, Research Center of the Mental Health Institute, Louis-H. Lafontaine Hospital, Canada*

[b] *Department of Psychiatry, Faculty of Medicine, University of Montréal, Canada*

[c] *School of Criminology, University of Montréal, Canada*

[d] *Psychology Department, McGill University, Montreal, Canada*

[e] *Department of Neurology and Neurosurgery, Faculty of Medicine, McGill University, Montreal, Canada*

[f] *Neuroscience Program, Faculty of Medicine, University of Montréal, Canada*

[g] *Translational Research Center for TBI and Stress Disorder, Boston VA Healthcare Center, Boston University, MA, United States*

[h] *Department of Psychology, University of California, Los Angeles, CA, United States*

[i] *Department of Family Medicine, Mayo Clinic, 200 First Street SW, Rochester, MN 55905, United States*

[j] *School of Psychoeducation, University of Montréal, Canada*

Abstract—Various studies have shown that increased activity of the hypothalamic–pituitary–adrenal (HPA) axis can predict the onset of adolescent depressive symptomatology. We have previously shown that adolescents making the transition to high school present a significant increase in cortisol levels, the main product of HPA axis activation. In the present study, we evaluated whether a school-based education program developed according to the current state of knowledge on stress in psychoneuroendocrinology decreases cortisol levels and/or depressive symptoms in adolescents making the transition to high school. Participants were 504 Year 7 high school students from two private schools in the Montreal area. Adolescents of one school were exposed to the *DeStress for Success Program* while adolescents from the other school served as controls. Salivary cortisol levels and depressive symptomatology were measured before, immediately after as well as 3 months after exposure to the program. Measures of negative mood were obtained at baseline in order to determine whether adolescents starting high school with specific negative moods were differentially responsive to the program. The results show that only adolescents starting high school with high levels of anger responded to the intervention with a significant decrease in cortisol levels. Moreover, we found that adolescents who took part in the intervention and showed decreasing cortisol levels following the intervention (responders) were 2.45 times less at risk to suffer from clinical and subclinical depressive states three months post-intervention in comparison to adolescents who showed increasing cortisol levels following the intervention (nonresponders). This study provides the first evidence that a school-based program on stress is effective at decreasing cortisol levels and depressive symptomatology in adolescents making the transition to high school and it helps explain which adolescents are sensitive to the program and what are some of the characteristics of these individuals.

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Key words: stress, cortisol, school, education program, depression, adolescents.

INTRODUCTION

Contrary to popular belief, children and adolescents are just as capable as adults of experiencing stress and the stress-related health outcomes that ensue (Lohman and Jarvis, 2000). The effects of stress on the well-being of children and adolescents are substantial, as stress has been shown to increase incidence of psychiatric problems at this period of development (Goodyer et al., 1996b; Rudolph and Hammen, 1999; Hudziak et al., 2000; Angold et al., 2002). Adolescence is also a period in which the long-lasting effects of earlier stress become evident. Adolescents who grew up in poor economic conditions have higher levels of stress hormones (Evans and English, 2002), as do adolescents whose mothers were depressed in the early postnatal period (Halligan et al., 2004). High early morning levels of stress hormones that vary markedly from day to day at the transition to adolescence are not associated with

*Correspondence to: S. J. Lupien, Director, Centre for Studies on Human Stress, 7331 Hochelaga, Montreal, Quebec, Canada H1N 3V2. Tel: +1-514-251-4015x2337; fax: +1-514-251-2616.
E-mail address: sonia.lupien@umontreal.ca (S. J. Lupien).
URL: http://www.humanstress.ca (S. J. Lupien).

Abbreviations: CDI, child depression inventory; HPA, hypothalamic–pituitary–adrenal; LGCM, latent growth curve model; NUTS, Novelty, Unpredictability, Threat to personality and Sense of low control; SES, self-esteem scale; VAMS, visual analog mood scale.

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depressive symptoms at that time, but predict increased risk for depression by age 16 (Halligan et al., 2007).

Depression is among the most prevalent of psychological disorders in children and adolescents. Approximately 2.5% of 13-year-olds experience depression. This rate rises to 17% among 18-year-olds and then remains at a high level across most of adulthood (Hankin et al., 1998; Angold et al., 2002; Abela and Hankin, 2008). Recent birth cohort data show that adolescence has become one of the most common periods for the onset of first episode depression (Kessler et al., 2005; Kessler and Wang, 2008). Sex differences in depression also emerge during this time period; starting in mid-adolescence, and persisting into adulthood to reach prevalence rates almost twice more in females as they are documented in males (Burke et al., 1994; Hankin et al., 1998).

Research shows that children and adolescents who lack the ability to appropriately manage chronic stress and negative emotions can experience a sense of hopelessness (McCraty et al., 1999) and tend to show more emotional and behavioral problems (Lazarus and Folkman, 1984). Given the adverse effects of stress on well-being and its potential implication in the vulnerability to adolescent depression, the need to provide children and adolescents with the skills to develop ways to manage and cope with stress is paramount. However, while research has increasingly examined the effects of stress-management techniques in adults (Murphy, 1996; Edwards et al., 2003; Gaab et al., 2003, 2006; Richardson and Rothstein, 2008) and children (for a review, see Pincus and Friedman (2004)), there is a paucity of research on how stress-management programs (educational or psychological) apply in adolescents.

Three types of prevention programs have been developed to target different populations. Universal programs are usually presented to all individuals regardless of symptoms and are often designed to build resiliency and/or enhance general mental health (Barrett and Turner, 2001). Selective programs are presented to individuals who are at risk of developing a mental health problem as a function of particular risk factors, while indicated programs are delivered to individuals who present mild or severe symptoms of a mental health disorder (Donovan and Spence, 2000).

When dealing with adolescents, the school system has been identified as being an ideal setting for the implementation of prevention programs (Masia-Warner et al., 2005) because this setting offers the unequaled opportunity to reach all adolescents, and thus avoid the selection bias of clinically referred samples defined based on the presence of mental health problems. This serves to reduce and alleviate many of the common barriers to treatment in the community such as those related to time, location, stigmatization, transportation and costs (Barrett and Pahl, 2006; Masia-Warner et al., 2006). Because universal interventions have the advantage of avoiding the stigma of singling out individuals for treatment (Rapee et al., 2006; Sheffield et al., 2006), some universal programs on stress have been developed for adolescents. For example, the *Gatehouse Project* was created to reduce stressors in the environment by creating a more inclusive classroom environment with a focus on improving interpersonal bonds (Patton et al., 2000, 2006). Similarly, the *Transition Club Project* was developed to help students gradually acclimate to the secondary school environment through pre-transition exposure (Humphrey and Ainscow, 2006). While most of the stress management programs can be time consuming, review of intervention programs in school settings show that even brief school-based intervention programs can have significant effects on stress management skills in children and adolescents (Pincus and Friedman, 2004).

Although some universal programs are reported to lead to significant psychological changes in the group of adolescents exposed to them, many reports indicate that most intervention programs exert a real, immediate and measurable effect only for a subsample of participants. For example, studies dealing with prevention of depressive symptoms in children and adolescents report that certain individual characteristics (e.g., age, gender, ethnicity, cognitive ability) moderate the effects of preventive interventions on depression (Horowitz and Garber, 2006). As well, in a study by Spaeth et al. (2010), it was shown that a universal school-based life skills program against substance misuse exerted a differential effectiveness for young adolescents according to their alcohol use trajectories characterized by late childhood risk factors such as temperament, self-worth, and social problems with peers (Spaeth et al., 2010).

The vast majority of programs for stress management developed to this day for adolescents are based on the appraisal model of Lazarus and Folkman (1984). Although many of these programs have revealed beneficial effects in adolescents, it is interesting to note that none of them have been developed in line with discoveries made in the last 35 years in the field of psychoneuroendocrinology, a field of research that measures the causes and consequences of physiological reactivity to psychological stress in humans. Moreover, and as summarized by Adam et al. (2010) in a recent review of the literature, there is no study to this day that assessed whether physiological measures of stress respond as efficiently to prevention programs as psychological measures do. Yet, it is the physiological response to stress that can get under the skin and the skull in order to exert a long-lasting influence on stress perception and coping and, in turn, underline vulnerability to various mental health problems in adolescents (for a review see Lupien et al. (2009)).

Psychoneuroendocrine studies performed in the last three decades in humans show that stress activates the hypothalamic–pituitary–adrenal (HPA) axis, leading to secretion of cortisol, the main stress hormone in humans. Various studies performed in both animals and humans have shown that chronic exposure to stress hormones from the prenatal period to aging impacts brain structures involved in cognition and mental health. Specific effects on the brain, behavior and cognition

emerge as a function of the timing and the duration of exposure to stress, and some of these effects depend on interaction between genes and exposure to environmental adversity (for a review, see Lupien et al. (2009)).

Research has identified four situational determinants that activates the HPA axis in humans, namely novelty (N), unpredictability (U), threat to personality[1] (T) and a sense of low control (S) [hence the acronym 'NUTS' in the *DeStress for Success Program* (Mason, 1968a; Dickerson and Kemeny, 2004). Both basal and stress-induced HPA activity is significantly heightened during adolescence (McCormick et al., 2004; Netherton et al., 2004).

There are indications that the adolescent human brain might be especially sensitive to the effects of elevated levels of glucocorticoids. Recent studies on the ontogeny of glucocorticoid receptor expression in the human brain show that their mRNA levels in the prefrontal cortex are relatively high in adolescence compared to infancy, young adulthood and senescence (Perlman et al., 2007). This suggests that there may be age-dependent sensitivity to glucocorticoid receptor-mediated regulation by glucocorticoids on cognitive and emotional processes that are regulated by these brain areas. Various forms of psychopathology, including depression increase in prevalence in adolescence (Dahl, 2004).

In a recent Canadian epidemiological study, authors reported that although social network and social support are important risk factors for depression, a higher perceived stress level increased the risk of depression by 2.9 in 15–24 year-old people (Nguyen and Fournier, 2007). Robust cross-sectional associations have been found between the presence of major depressive disorder and a variety of alterations of the HPA axis, including elevated cortisol levels (Ehlert et al., 2001), but whether HPA dysregulation is a consequence or a marker of vulnerability to depression required results of prospective studies.

In adolescents at high risk for psychopathology, such studies showed that the occurrence of peaks in morning cortisol (higher than the 80th percentile) increased by 2.9 the risk of subsequent major depressive disorders (Goodyer et al., 2000). In a longitudinal study of adolescents with major depressive disorder, the combination of elevated free urinary cortisol and recent stressful experiences predicted recurrence in depression (Rao et al., 2010). In another study with adolescents from a community sample, elevated morning salivary cortisol at 13 years, and particularly the maximum level recorded over 10 days of collection, predicted elevated depressive symptoms at 16 years (o.r. = 1.37) over and above possible confounding factors, including 13-year-old depressive symptoms (Halligan et al., 2007). In a wider study from a community sample of 17–18-year-old adolescents, Adam et al. (2010) reported that the levels of the cortisol awakening cortisol response increased significantly the risk of major depressive disorder (o.r. = 2.96), 1 year later. Finally, in a study of offspring of parents with bipolar disorder, it was found that cortisol levels measured at 17 years of age predicted the development of an affective disorder during the subsequent 2.5 year after controlling for offspring mental disorders at the first assessment, and having a parent with bipolar disorder (Ellenbogen et al., 2011).

Altogether, these results suggest that high levels of stress hormones may therefore be a key component of the onset and maintenance of depressive symptomatology and consequently, both measures (stress hormones and depressive symptomatology) should be assessed prospectively in studies testing the efficacy of preventive programs on stress.

In a previous study performed in 406 children and adolescents, we reported that the transition from Grade 6 (elementary school) to Grade 7 (high school) is associated with a significant increase in cortisol levels in adolescents from both low and high socio-economic strata (Lupien et al., 2001). This finding suggested that this life transition may represent a significant stressor in the life of adolescents (for a review, see Lupien et al. (2001)). Transition to high school has been reported to be associated with negative outcomes including poorer attendance, declines in grades, newly emerging disciplinary problems, and new feelings of alienation or social rejection (Moyer and Motta, 1982) as well as a decline in a sense of school belongingness and an increase in depressive symptoms (Newman et al., 2007).

Based on these findings, we developed the *DeStress for Success Program* to expand youth awareness and scientific knowledge on identifying and coping with stress (Table 1). The uniqueness of the *DeStress for Success Program* lies primarily in its theoretical framework rooted in Psychoneuroendocrinology. Specifically, stress is recognized and deconstructed based on the four important ''NUTS characteristics'' reported to lead to significant activation of the HPA axis (Mason, 1968b; Dickerson and Kemeny, 2004). Secondly, the program explains the stress response and ways to use the body to stop it. Finally, it is a relatively short program, easy to implement in school-settings.

Similarly to universal programs aimed to reduce depressive symptomatology and prevent drug use in adolescents (Horowitz and Garber, 2006; Spaeth et al., 2010), we are expecting large individual differences in HPA axis activity among participants who completed the program – some showing lower cortisol levels whereas others having unchanged or even increased cortisol levels. This is consistent with the known relative impact of social environments on the HPA axis according to differences rooted in genetic factors, sex, personality as well as psychological and emotional states (Gotlib et al.,

[1] The notion of 'threat to personality' used in the present paper and in the *DeStress for Success Program* refers to the notion of 'socio-evaluative threat' proposed by Dickerson and Kemeny (2004) and Mason (1968a,b) in their description of predictors of laboratory stress reactivity in humans. In our education program with adolescents, we have developed the notion of 'threat to personality' as a synonym of conditions that threaten the social self – meaning social-evaluative threat – because we found in previous focus groups with teenagers that the notion of 'social evaluative threat' is not well understood by adolescents. In contrast, the notion of 'threat to personality' is very well understood by this age group.

Table 1. Summary of the *DeStress for Success Program*

Session 1: Recognizing Stress: NUTS	– What is stress? – Elements of stress – NUTS Model of Stress (Novelty, Unpredictability, Threat to personality, Sense of low control)
Session 2: Application of the NUTS Model of Stress	– Application of the NUTS model to identify and deal with daily stressors – Individual interpretation of stressful events
Session 3: The Body's Response to Stress	– Recognition of body's response to stress – Energy mobilization – Physical signs of stress – Ways the body gets rid of built up energy – Strategies to cope with stress (Emotion-focused coping)
Session 4: Dealing with Stress: Do not go NUTS!	– Coping Strategies (Problem-focused coping) – Utilize NUTS Model to deconstruct real-life stressors
Session 5: The importance of others: Social Support versus Social Pressure	– The Trier Social Stress Test is used with students to demonstrate the concept of social support – Line Experiment – to demonstrate social support *versus* social pressure as coping strategies to stress

2008; Kudielka et al., 2009; Ouellet-Morin et al., 2009). Accordingly, in addition to testing the main effect of *DeStress for Success Program* on cortisol reduction for all participants, we will also investigate the possibility that the lowering cortisol effect may be detected only in a subsample of our participants.

The present study tested the efficacy of the *DeStress for Success Program* on both cortisol levels and depressive symptomatology in adolescents making the transition to high school. This study had three objectives. First, we determined whether, on average, the adolescents participating in the *DeStress for Success Program* showed declining levels of cortisol across time. Second, we examined whether our intervention benefited, in terms of cortisol reduction over time, to some adolescents more than others. To do so, we tested whether larger decreases of cortisol from baseline to three months following the end of the intervention were associated with age, sex and a series of psychological measures (depressive symptomatology, self-esteem and mood state). Third, we further investigated if the adolescents with the largest responses to the intervention, as indicated by a greater decline of cortisol over time, reported less depressive symptoms three months later in comparison to those who did not show such cortisol decreases.

EXPERIMENTAL PROCEDURES

Methods

Participants. A total of 504 adolescents (260 boys and 244 girls) aged 11–13 years (mean age: 12.02 ± 0.26 years) were recruited from two private secondary schools in Montreal, Quebec, Canada. Following the Quebec education system, participants were first year high school students (Grade 7). Participating students were from families of middle to high socioeconomic status, all French speaking. The Intervention School was from a suburban area in the Montreal region, while the Control School was from an urban school located in the North of Montreal. In Quebec, school start time is dependent upon the school bus system so that some high schools may start as early as 7:00 am to allow buses to arrive at the school as a function of traffic, while other high schools can start as late as 9:40 am. In our study, the Intervention School started at 9:40 am, while the Control School started at 8:20 am.

While all students who provided consent took part in the program, participant's inclusion for study analyses included being free of medication that may affect depressive symptoms or cortisol levels (e.g., anti-asthma medication, anxiolytics etc.), and not presenting other psychiatric, neurological, substance use or general health. The ethics committees at the Douglas Mental Health University Institute and Louis-H. Lafontaine Mental Health University Institute approved this study. In addition, approval for the study was obtained from each school board. Adolescents' parents signed a consent form, while the adolescents signed an assent form. Parental consent was obtained for 90% of adolescents in the Intervention School and for 75% of adolescents in the Control School.

Given that this was a universal program aimed to take place in schools, it was deemed important to control for contamination from the active treatment to the comparison group. Indeed, if we divided a school in half (with 50% of students receiving the program and the other 50% not receiving it), those in the program were almost certainly going to talk to their excluded peers about their experiences of the program or directly apply the techniques taught in the program at the school setting. School authorities were not in favor of such a method because it would potentially benefit to only half of the adolescents. To control for these factors, the Intervention School ($N = 284$) received the program during the fall semester, while the Control School ($N = 220$) was assigned to the delayed intervention and received the program during the spring semester. The adolescents from both schools were measured for cortisol levels and depressive symptomatology at three times during the fall semester. Although there were no differences between these cohorts on variables such as socioeconomic status or gender composition, we were aware that this design could create a potential confound related to a cohort effect. Because of this, we first performed preliminary analyses in order to compare the two schools on a series of potential confounders and initial differences in psychological variables.

Measures

Demographics. In order to assess whether adolescents from the two schools were different on demographic factors, we assessed age of the adolescents, as well as height and weight. As well, variables related to time of awakening and delay between time of awakening and start of school were compared across groups.

Salivary cortisol. To assess stress hormones levels, two measures of salivary cortisol were taken at each testing session. Sample 1 was taken at the start of the testing session, and Sample 2 was taken at the end of the testing session. Approximately 45 min elapsed between retrieving Samples 1 and 2 from all of the participants. The process was repeated for each testing session.

Scheduling constraints imposed by the direction of each school limited our control over which groups (classes) the research team could test and when. The Intervention School allowed testing to take place at different times over the course of the day (am and pm) throughout the entire period of the study (5 months), while the Control School only allowed testing at the end of classes during students' mandatory study period (pm only). Due to these constraints, we needed to control for the variations in cortisol levels imposed by these schedules. This was done by examining cortisol secretion using a latent growth curve model (LGCM). This model estimates separately, but simultaneously, the mean cortisol level prior to the intervention (intercept) and the cortisol change occurring subsequently (slope). The main advantages of LGCM over repeated measures ANOVAs are that the dependent structure of the data can be modeled through the estimation of fixed and random coefficients (corresponding to the parameters' mean and variance across individuals, respectively), the unequal observations across individuals can be included and the adequate statistical control for time-varying covariates, such as collection time, is allowed. This latter feature is of particular interest for studies conducted outside the laboratory (including the present one) and for which saliva samples are collected at different times of the day across multiple waves of data collection. Consequently, all data related to cortisol in Tables and Figures represent Z residuals of cortisol levels in μg/dl obtained after a log 10 transformation performed in order to normalize the distribution.

Participants were provided with saliva tubes (Sarstedt©, tubes Part No. 62.558.201) and oral instructions for proper collection. Participants provided 2 mL of pure saliva (no cotton swab) in the saliva tube. At the end of each testing session, saliva samples were stored in freezers at −20 °C at the Centre for Studies on Human Stress (www.humanstress.ca) until determination using a high sensitivity enzyme immune assay kit (Salimetrics® State College, PA, Catalogue No. 1-3102). Frozen samples were brought to room temperature to be centrifuged at 15,000*g* (3000 rpm) for 15 min. The range of detection for this assay is between 0.012 and 3 μg/dL. Upon receiving duplicate assay values for each sample, we averaged these values together. The two cortisol samples taken at each testing session were averaged to account for intra- and inter-individual variability during group testing (Lupien et al., 2001). This protocol was employed to minimize the potentially confounding influence of extraneous factors (e.g., food intake, tester-effects, novelty, etc.) that can distort the representation of a single measurement.

Depressive symptoms

The 27-item French-validated version (Saint-Laurent, 1990) of child depression inventory (CDI) developed for children and adolescents aged 7–17 (Kovacs, 1981, 1991) was administered to measure self-rated depressive symptoms. Each item contains three choices, ranging from 0 to 2, providing a possible score between 0 and 54. To standardize scores, our statistical analyses used *t*-scores transformed from the raw data. Total scores on the CDI (*t*-scores) served as the primary measure of self-rated depressive symptoms.

For ethical reasons, all students were actively monitored by the research team and those who scored in the clinical (score higher than 20) or subclinical (score between 12 and 19) range of symptomatology according to the known CDI cut-off points were considered in potential need of clinical intervention and were referred to the school psychologist for additional assessment and potential treatment. Adolescents and parents were informed about this procedure when they signed the consent and assent forms. As a result of this procedure, 42 adolescents were referred to the school psychologist for clinical/subclinical scores on the CDI after one or more of the three testing sessions (23 adolescents from the Intervention School and 19 adolescents from the Control School). All adolescents referred to the school psychologists were allowed to pursue participation into the *DeStress for Success Program* and their data were included in the analyses.

Rosenberg self-esteem scale (SES)

The Rosenberg SES (Rosenberg, 1965) was used to measure self-esteem. The Rosenberg scale is a 10-item self-report measure of global self-esteem. It consists of 10 statements related to overall feelings of self-worth and self-acceptance. The items are answered on a four-point scale ranging from "strongly agree" to "strongly disagree". The Rosenberg Self-Esteem Scale was originally developed to assess self-esteem among adolescents. It is a brief and one-dimensional measure of global self-esteem. The Rosenberg Self-Esteem Scale has demonstrated good reliability and validity across a large number of different sample groups. The scale has been validated for use with both male and female adolescent, adult and elderly populations (Rosenberg, 1965).

Visual analog mood scale (VAMS)

Presence of positive or negative mood in adolescents was assessed with the VAMS. The VAMS is a reliable and valid (Folstein and Luria, 1973; Fahndrich and Linden, 1982) measure of eight specific mood states assessed on a 1–100% Likert scale: Afraid, Confused, Sad, Angry, Energetic, Tired, Happy, and Tense. This simple, brief test places minimal cognitive or linguistic demands on the respondent (Stern et al., 1991).

Protocol

DeStress for Success Program. The *DeStress for Success Program* is a fully manualized educational group program available from the first author. During the academic year, students received five 40-min workshops as part of the *DeStress for Success Program*. The Intervention School received the program in the fall semester, and the Control School received it in the spring semester, after termination of the study. The workshop presenters were trained graduate students and research assistants from the CSHS. The program was created by members of the CSHS (www.humanstress.ca), in collaboration with educators, school nurses, counselors and adolescents and it was based on all the available psychoneuroendocrine data obtained in humans in the last 35 years.

Table 1 presents a short description of the workshops. The first workshop called *"Recognizing Stress: NUTS"* involves the description of what is stress and how we can recognize it. A stressful situation is characterized by four main characteristics: Novelty, Unpredictability, Threat to personality and Sense of low control (NUTS). Interactive games are performed with adolescents in order to teach them these characteristics and how to recognize them and remember them (using the word "NUTS" is a method). The second workshop called '*Application of the NUTS Model of Stress'* uses homework completed independently by the adolescents on the NUTS concept of stress to support their understanding that (1) different situations

lead to stress for different reasons and (2) different persons may produce a stress response to a similar situation, but for different NUTS reasons. This helps adolescents identify their own stressors and to contextualize their most likely sources of stress compared to their friends. The third workshop called '*The Body's Response to Stress'* teaches adolescents how to recognize when they are producing a physiological stress response and it presents the concept of energy mobilization. Adolescents learn how to deal with the mobilized energy and how to get rid of it in order to prevent accumulation of stress. The fourth workshop called '*Dealing with Stress: Don't go NUTS!*' involves helping the adolescent recognize the different methods that someone can use to deal with a stressful situation (avoidance, emotion-based coping, problem-oriented coping). We help them understand that each of these methods could be, inherently, a good coping strategy, although its efficiency may depend on the stressor/context/persons involved. Finally, the fifth workshop called '*The importance of others: Social Support versus Social Pressure*' teaches adolescents about the importance of having social support in times of stress but it also teaches them that sometimes, social support can become social pressure. Interactive games are performed with adolescents in order to help them differentiate providers of social support *versus* providers of social pressure in their environment. The fifth workshop ends with a short survey asking adolescents to rate their appreciation of the *DeStress for Success Program*.

Testing sessions. Fig. 1 presents a schematic representation of the testing sessions that occurred in the intervention and control schools. Adolescents from the intervention and control schools were tested for cortisol levels and psychological variables during school hours on three occasions, i.e. pre-intervention, post-intervention and follow-up. At both schools, pre-intervention (T1) occurred during the first and second weeks of September and the *DeStress for Success Program* was delivered for 5 weeks (from the third week of September to the end October) in the Intervention School while adolescents in the Control School continued their normal activities during this period (they received the program in the spring semester). The post-intervention measure (T2) was obtained in November in both schools and the follow-up measure (T3) was obtained in December for both schools. All three assessments had the same measures (cortisol and psychological variables) and there were no differences in assessment conditions for the intervention and control groups. In order to assess whether exposure to the *DeStress for Success Program* had an effect on depressive symptomatology subsequently to the follow up period, the CDI questionnaire was given a fourth time in the Intervention School, at the end of January, 3 months post-intervention.

The large number of participants necessitated three consecutive days of testing for every data wave collection for each school. Data collection took place on Mondays, Tuesdays, and Wednesdays, with some exceptions due to rescheduling issues. The total number of visits to the school was approximately 18 for testing, plus five more visits to teach the *DeStress for Success Program*. Students were tested during class time or study period, using a group-testing method. At the start of each 45-min testing session, participants provided their first saliva sample. A demographics questionnaire was completed in the first testing session, providing information on the student's sex, age, height, weight, medication use and medical conditions. This was followed by a series of cognitive and psychological questionnaires that were completed at each testing session. At the end of each testing session, a second saliva sample was obtained.

Data analyses

Groups were first compared on demographic, psychological and sleep-related variables using univariate analyses. Then, as described previously, and due to the fact that cortisol levels were ascertained at different times of the day across testing sessions, we examined cortisol secretion using a LGCM. Models were fitted in Mplus Version 6.11 (Muthén, 1998–2008) using maximum likelihood estimation. All models were evaluated using recommended fit indices, including: Root Mean Square Error of Approximation (RMSEA), where values $< .08$ indicate 'acceptable' fit and values $< .05$ indicate 'good fit'; Confirmatory Fit Index (CFI), where estimates $> .90$ indicate 'acceptable' fit and values $> .95$ indicate 'good' fit; and the Standardized Root Mean Square Residual (SRMR), where values $< .08$ are considered acceptable (Hu and Bentler, 1999; McDonald and Ho, 2002).

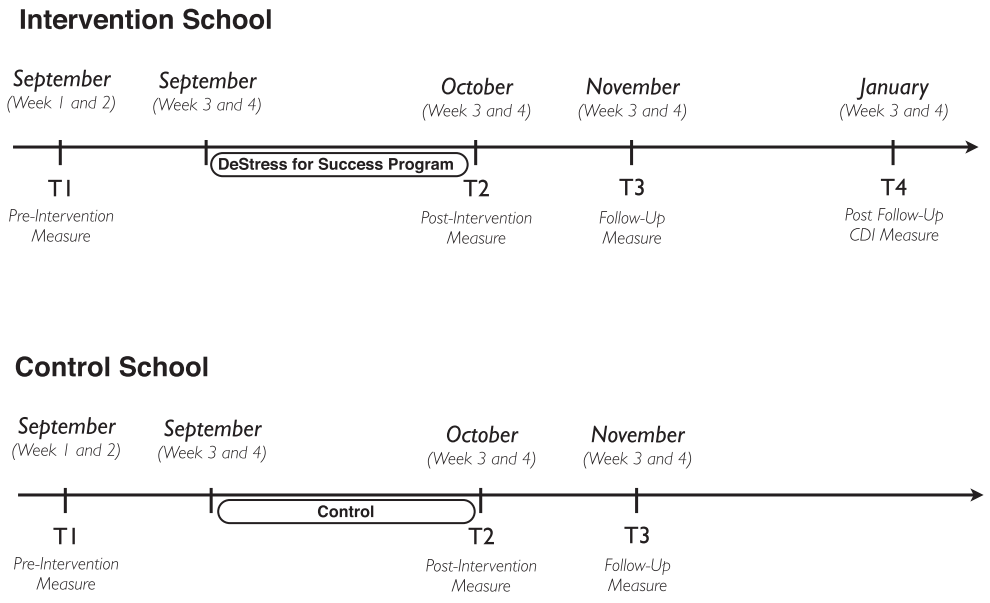

Fig. 1. Schematic representation of the experimental design and testing periods for the intervention and control schools.

Table 2. Comparison of the Intervention School and the Control School on demographic, psychological and sleep variables

	School 1/intervention group	School 2/control group	Group difference
Demographic variables			
N total	284 (51.8% girls)	220 (44.1% girls)	–
Age	11.81 ± 0.02	12.04 ± 0.02	*
Height	61.05 ± 0.53	64.03 ± 0.65	**
Weight	95.7 ± 1.13	103.4 ± 1.58	**
Psychological variables			
Depressive Symptoms	6.88 ± 0.3	8.02 ± 0.3	**
Self-Esteem	33.12 ± 0.27	32.84 ± 0.32	Ns
Scared	24.86 ± 1.24	23.3 ± 1.36	Ns
Confused	19.37 ± 1.06	31.12 ± 1.8	**
Sad	20.59 ± 1.11	22.71 ± 1.5	Ns
Angry	20.88 ± 1.09	20.89 ± 1.41	Ns
Energetic	72.91 ± 1.44	72.51 ± 1.69	Ns
Tired	35.20 ± 1.4	43.83 ± 1.76	**
Happy	81.34 ± 1.14	78.36 ± 1.51	Ns
Tense	31.34 ± 1.53	40.33 ± 1.79	**
Sleep variables			
Time of awakening on weekdays	7.16 ± 0.04	6.47 ± 0.03	**
Time of awakening on weekends	8.95 ± 0.07	9.08 ± 0.09	Ns
Time leave home for school	8.4 ± 0.03	7.33 ± 0.02	**
Time arrive at school	9.04 ± 0.04	7.93 ± 0.03	**

* Significant group difference at $p < 0.05$.
** Significant group difference at $p < 0.01$.

The differences observed on key demographic, psychological and sleep-related factors suggest the presence of two different cohorts of adolescents defined by their school (see results section and Table 2). As a result, we cannot test for the presence of mean cortisol differences between the schools while statistically controlling for these confounders without exceedingly constraining the variance left to identify the participants exposed or not to the intervention (i.e., intervention and the control schools). However, we took advantage of this case-control design indirectly by investigating whether the individual characteristics shown to modulate the cortisol response to the intervention were also intervening in temporal change in cortisol levels over the same period of time in adolescents unexposed to the intervention. This methodology allowed us to explore the specificity of the effects reported in the context of the intervention.

We tested our objectives in three steps. First, we captured the changes in the pattern of cortisol secretion in the intervention group by estimating the intercept and the slope. Second, we tested whether distinct patterns of cortisol response to the intervention may have emerged as a function of adolescents' individual characteristics such as age, sex and indicators of psychological variables at baseline (continuous depression scores, self-esteem and mood). We then carried out a multivariate analysis to identify which factors were uniquely associated with the cortisol intercept and the slope. Thereafter, we wanted to distinguish whether the individual factors shown to affect cortisol decrease over time (slope) were triggered only in the specific context of our intervention or were they involved, more generally, in the cortisol intra-individual variation in adolescents of this age. To do so, we tested whether the intervention moderated the associations between the previously identified individual factors and cortisol change over time by including an interaction term (school X individual factors) in the regression models. The presence of an interaction indicating an association between the slope and the individual factors solely in the school where intervention took place would suggest the facilitating role of the intervention in this process. Third, we extracted the intercept and slope estimates derived in Mplus and split the sample into two groups according to the lowest third of the slope's distribution: (1) adolescents who had the largest cortisol decline over time (responders) and (2) those who did not show this pattern of secretion (non-responders). We then tested whether the adolescents who respond to the intervention, in terms of cortisol reduction, reported better psychological functioning three months later in comparison to the non-responders using logistic and linear regressions models (for dichotomous and continuous outcomes, respectively). Depressive symptoms were then considered as the presence or absence of a depressive state based on the established CDI cut-off scores (Kovacs, 1981, 1991). We repeated these analyses to test whether these effects remained if we control for pre-existing individual differences in each of these indicators.

RESULTS

Preliminary analyses

Group comparisons performed on the demographic, psychological and sleep-related variables are presented in Table 2. In terms of demographic variables, it was found that adolescents from the Control School were significantly older, taller and weighted more than adolescents from the Intervention School. Although the group difference in age was not very important (11.8 years in the Intervention School and 12.04 years in the Control School), it could very well explain the greater height and weight of adolescents in the Control School.

Adolescents from the Control School reported significantly higher depressive symptoms, and reported greater feelings of confusion, fatigue (tired) and tension when compared to adolescents from the Intervention School. Finally, adolescents from the Control School woke up significantly earlier than adolescents from the Intervention School, an effect that may be due to the earlier start time at the Control School (8:20 am) when

compared to the Intervention School (9:40 am). However, adolescents from the two schools did not differ on time of awakening on weekends, suggesting that the group difference observed on awakening time on weekdays is due to difference in school start time. The difference is such that the time of awakening on weekdays almost defined the belonging of adolescents to the intervention/control groups, with the consequence that if we were to control for this potential confounder, there would be almost no variance to test the difference in cortisol between the intervention and control schools. Based on this important cohort effect, we only considered the Intervention School in the analyses with the exception, as stated before, to compare whether the mechanisms observed in the context of the Intervention School also took place in the context of the Control School.

Do adolescents show, on average, decreasing levels of cortisol following the intervention?

Table 3 presents the fixed and random effect estimates of the mean cortisol levels prior to the intervention (intercept) and the slope. We first tested whether as a group, adolescents who were exposed to the *DeStress for Success Program* showed a significant decrease of cortisol. As shown in Table 3, adolescents had a mean cortisol value of 4.66 μd/dl and did not show a significant overall decrease of cortisol following the end of the intervention. This finding suggests that the program did not, on average, trigger a significant decrease of cortisol in the adolescents exposed to it over the following month and a half. However, the variance terms indicated that adolescents varied significantly from one another on their cortisol levels prior to the intervention (intercept) and with respect to how they changed subsequently (slope), suggesting that individual characteristics may partly underline such differences. The covariance between the intercept and the slope indicated that the level of cortisol prior to the intervention was not associated with the cortisol change over time (Table 3).

Table 3. Fixed, random and covariance estimates of cortisol levels prior to and following Destress for Success in the total sample of children (n = 284)

Parameters	Statistics		
	B	S.E.	Critical ratio C.R.
Fixed (means)			
Intercept (y_0)	4.66	1.27	3.67***
Slope (y_s)	−.35	1.00	−.35
Random (variances)			
Intercept (σ_0)	.72	.21	3.47***
Slope (σ_s)	.25	.12	2.02*
Covariances			
Intercept–slope (y_0, y_s)	−.16	.13	−1.24

Note: The fixed estimate of the intercept represents the mean cortisol level prior to the intervention (baseline) while the fixed estimate of the slope reflects the change of cortisol (nmol/L) per one month interval. These estimations take into account the exact time of saliva collection. B = unstandardized beta estimate; S.E. = standard error. The critical ratio refers to the ratio of the unstandardized beta estimate over the standard error (B/S.E.). Fit statistics: χ^2 = 2.53, df = 3, CFI = 1.00, RMSEA = .000, SRMR = .021.

* $p < .05$.

*** $p < .001$.

Do cortisol level prior to the intervention and change following the intervention differ according to individual characteristics?

As specified in Table 4, age, depressive symptoms and self-esteem were not associated with the adolescents' mean cortisol level prior to the intervention or their subsequent rate of change. However, we observed a higher mean cortisol level at baseline in females in comparison to males [Critical Ratio = 3.73, $p < .001$] (Table 4, Model 1). Males and females did not otherwise show distinct patterns of cortisol change following the intervention. Mood disturbances related to anger and tension were also significantly associated with the intercept and/or slope. As shown in Fig. 2, adolescents who reported more anger prior to the intervention had higher cortisol levels prior to the intervention and showed larger cortisol decreases subsequently [intercept: Critical Ratio = 2.41, $p = .01$; slope: Critical Ratio = −2.70, $p = .007$] (Table 4, Model 1). A similar pattern of result was detected for tension, where adolescents who expressed more tension had greater cortisol decreases following the intervention [Critical Ratio = −2.10, $p = .04$]. The multivariate analysis indicated that only sex and anger were uniquely associated with the intercept and the slope whereas tension did not uniquely predict cortisol responses to the intervention over and above sex and anger (Table 4, Model 2).

To investigate the specificity of anger as a predictor of the cortisol response to the intervention, we contrasted this finding with the intra-individual cortisol changes measured concurrently in the Control School not exposed to the program. While controlling for the above-mentioned association between sex and the intercept, we detected a significant moderating effect of the school on the association between anger and the cortisol slope [Critical Ratio = 2.58, $p = .01$]. The breakdown of this interaction showed that in contrast to the school where the intervention took place and where anger was associated with larger decreases of cortisol over time (Table 4), this association was not significant at the school unexposed to the intervention [Critical Ratio = .83, $p = .41$]. Fig. 1 (top panel) illustrates the decreasing cortisol levels noted in adolescents who participated in the intervention and reported the highest levels of anger (the top third of the distribution) whereas no changes were seen for the remaining participants with less or moderate levels of anger (i.e., the first and second third of the distribution). In contrast, for the school not exposed to the program (bottom panel), adolescents who reported high levels of anger did not show a decrease in cortisol levels but rather a non-significant trend toward increasing levels toward the testing sessions. These findings suggest that adolescents with high levels of anger prior to the intervention benefit the most from the program, an effect that was unique among the adolescents who

Table 4. Associations between each potential predictor and cortisol intercept and slope (Models 1) and while accounting for all the other significant predictors

Parameters	Models 1						Model 2					
	Intercept			Slope			Intercept			Slope		
	B	S.E.	C.R.	B	S.E.	C.R.	B	S.E.	C.R.	B	S.E.	C.R.
Age	.01	2.79	.003	−.20	1.99	−.10						
Sex	10.95	2.94	3.73***	−3.65	2.15	−1.70	8.13	2.26	3.59***	–	–	–
Depression	.05	.29	.16	.09	.21	.43						
Self-esteem	−.30	.33	−.91	−.02	.24	−.10						
Mood												
Scared	−.01	.07	−.13	−.01	.05	−.22						
Confused	.15	.09	1.82	−.05	.06	−.89						
Sad	.13	.08	1.55	−.11	.06	−1.85						
Angry	.20	.08	2.41*	−.16	.06	−2.70**	.18	.08	2.21*	−.14	.06	−2.24*
Energetic	.002	.06	.04	.001	.05	.02						
Tired	.06	.06	.89	−.06	.05	−1.31						
Happy	.02	.08	.26	−.07	.06	−1.14						
Tense	.08	.06	1.38	−.09	.04	−2.10*	–	–	–	−.05	.03	−1.45

Note: B = unstandardized parameter estimate; S.E. = standard error; C.R. = critical ratio. The critical ratio refers to the ratio of the unstandardized beta estimate over the standard error (B/S.E.). Fit statistics of Model 2: χ^2 = 31.25, df = 12, CFI = .83, RMSEA = .08, SRMR = .04.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

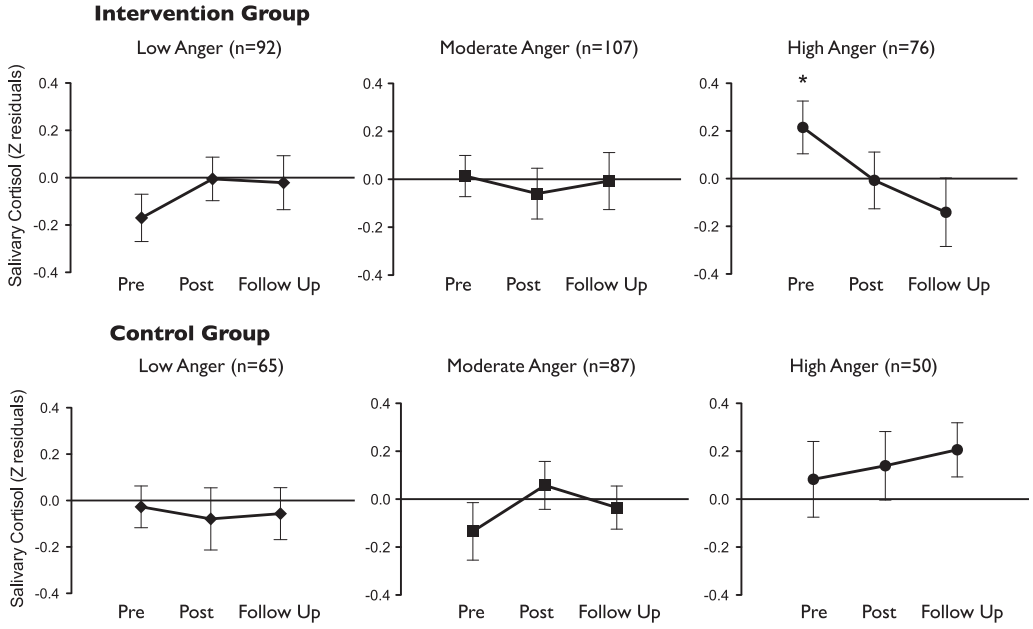

Fig. 2. Salivary cortisol levels (expressed as Z residuals controlling for time of sampling for each participant) at pre-intervention, post-intervention and follow-up in adolescents split into low, moderate and high anger in the intervention (upper panel) and control (lower panel) groups. ∗ Represents a significant decrease of salivary cortisol over time ($p < 0.05$).

participated in the intervention and not otherwise observed in its absence.

Do adolescents exhibiting the largest decreasing cortisol levels following the intervention reported a better psychological functioning later on in comparison to the remaining ones?

Table 5 (model 1) shows that adolescents with increasing cortisol levels over time (non-responders) were 2.45 times more at risk to suffer from clinical and subclinical levels of depressive states one month later in comparison to adolescents with decreasing cortisol levels following the intervention (responders; 8.2 *versus* 18.0 of having a CDI score above the subclinical or clinical threshold). Importantly, this association held when individual differences on depressive symptoms prior to the intervention were accounted for [Critical

Table 5. Mean differences between children who had the largest decrease in cortisol levels from T1 to T3 (responders) and those who did not (non-responders) on psychological indices measured three months after the end of the intervention (T4; Model 1), and over and above individual differences at T1 (Model 2)

Outcome at T4	Mean (SD) or %		Model 1 (unadjusted)			Model 2 (adjusted)		
	Responders	Non-responders	B	S.E.	O.R./ß	B	S.E.	O.R./ß
Depression	8.2	18	.90	.44	2.45*	.97	.47	2.64*
Self-esteem	35.91 (4.14)	35.05 (5.03)	−.86	.63	−.08	−.76	.52	−.07
Mood								
Scared	20.12 (21.30)	17.73 (5.03)	−2.38	2.69	−.05	−2.63	2.52	−.06
Confused	18.24 (17.40)	24.15 (21.30)	5.92	2.65	.14*	6.20	2.57	.14*
Sad	18.88 (20.33)	18.44 (18.60)	−.44	2.52	−.01	1.24	2.26	.03
Angry	20.18 (20.74)	19.81 (18.09)	−.37	2.49	−.009	1.33	2.38	.03
Energetic	80.00 (21.88)	72.38 (22.29)	−7.62	2.91	−.16**	−4.34	2.53	−.09+
Tired	34.65 (25.60)	35.74 (24.28)	1.09	3.24	.02	1.71	3.01	.03
Happy	85.41 (18.23)	81.51 (19.40)	−3.90	2.50	−.10	−3.17	2.34	−.08
Tense	25.65 (19.32)	25.96 (22.21)	.31	2.80	.007	1.58	2.63	.04

Note: No significant gender moderation effects were detected. Therefore, all analyses were conducted on the combined sample of boys and girls. B = unstandardized beta; S.E. = standard error.

+ $p < .10$.

* $p < .05$.

** $p < .01$.

Ratio = 2.64, $p = .04$]. A similar protective effect of being responders was noted on confusion. Specifically, the responding adolescents reported lower levels of confusion in comparison to the non-responders [ß = .14, $p = .03$]. Again, the association remained significant once pre-existing differences were controlled for [ß = .14, $p = .02$]. Finally, while responding adolescents reported more energetic mood two months after the end of the intervention, only a trend for significance was noted when initial differences were accounted for (Table 5, Model 2).

DISCUSSION

In the present study, we found that although as a group, adolescents exposed to the *DeStress for Success Program* did not show a significant decrease of salivary cortisol levels across time, adolescents who started the school year with high levels of anger benefited significantly from exposure to the program. This association between anger and cortisol decrease over time was not observed in the group not exposed to the intervention where adolescents with high levels of anger showed a trend toward increase in salivary cortisol levels over time.

Gillham et al. (2001) proposed that the term '*prevention*' be used to describe those programs that result in the diminution of an expected increase in symptoms or any given variable thought to have negative effect relative to controls. According to that definition, we report a preventive effect of the *DeStress for Success Program* since we found a significant decrease of cortisol levels among members of the intervention group. However, we see that this preventive effect of the *DeStress for Success Program* is only present for those adolescents starting high school with high levels of anger.

The second important finding of this study is that adolescents from the intervention group who showed increasing cortisol levels over time (non-responders) were 2.45 times more at risk to suffer from subclinical or clinical depressive states three months post-intervention in comparison to adolescents from the intervention group who showed decreasing cortisol levels following the intervention (responders). This result is in line with the proposed involvement of the HPA axis in the development of depressive symptoms in adolescents (Goodyer et al., 1996a; Halligan et al., 2007). Alternatively, it is possible that adolescents who go on and develop subclinical or clinical depressive states during the school year present a parallel increase in cortisol levels that cannot be prevented by exposure to the *DeStress for Success Program*. Heim et al. (2008) have suggested distinct etiologies of subtypes of clinical depression according to HPA axis disruptions and they proposed that these different etiologies could be related to childhood trauma. If this is the case, then it would imply that although the program has beneficial effects for adolescents with high levels of anger, it does not affect differently adolescents according to their depressive symptomatology prior to the beginning of the intervention. Consequently, it may be advisable to refer adolescents with subclinical or clinical depressive states to interventions specifically designed to address this issue rather than anticipate a reduction in depressive symptoms through the lowering effects of a universal prevention program on stress such as ours.

A recent meta-analysis that assessed the efficacy of 30 prevention programs for depressive symptoms developed for children and adolescents (Horowitz and Garber, 2006) reported that selective and indicated programs are significantly more effective than universal programs at decreasing depressive symptoms. Our results are consistent with this suggestion as we have shown that as a group, adolescents exposed to the

DeStress for Success Program did not show a decrease of salivary cortisol levels across time, but that only those adolescents who responded to the program with a significant decrease of cortisol levels presented significant changes in depressive scores. This result suggests that the *DeStress for Success Program* could be adapted and/or modified in order to become a selective or indicated program targeting adolescents with behavioral difficulties and emotional regulation deficits such as anger. These variations of the *DeStress for Success Program* are already under way at the Centre for Studies on Human Stress (www.humanstress.ca) as the program is now being adapted for difficult adolescents from youth services (Plusquellec et al., 2012).

Interestingly, in the present study using a universal prevention program, we found that only those adolescents responding to the program with a significant decrease in salivary cortisol levels presented significant improvements in depressive symptoms. In the totality of studies performed in the past and assessing the efficacy of prevention programs for depressive (Horowitz and Garber, 2006) or anxiety symptomatology (Neil and Christensen, 2009) in adolescents, no physiological measures of stress were obtained. We are not aware of any study that has tracked changes in cortisol levels over time in adolescents exposed or not to a prevention program targeting stress. The only two studies published to this day and that measured cortisol levels before and after an intervention were performed in infants and toddlers entering foster care (Dozier et al., 2006; Fisher et al., 2006). These studies showed that children in the experimental group (in which parents received an intervention for foster care) had lower cortisol levels than children in the control intervention.

The paucity of studies assessing the efficacy of prevention programs for stress, anxiety or depressive symptoms using physiological measures of stress is intriguing since a great number of studies now suggest that HPA axis changes in response to chronic stress may be part of the causal pathway by which environmental stress contributes to the development of anxiety and/or depressive symptomatology (for a review, see Lupien et al. (2009)). As argued by Adam et al. (2010) and by van Goozen and Fairchild (2008), it is imperative to incorporate HPA measures into preventive interventions for children and adolescent as an indicator of the extent to which a given prevention or intervention program is working and for whom it is working.

To our best knowledge, this is the first study to have followed the guidelines proposed by Adam et al. (2010) in adolescents and we show that incorporation of physiological measures of stress in studies assessing the impact of prevention programs on stress can lead to very important and informative data. Indeed, we found that physiological measures of stress helped explain which adolescents are sensitive to the program (and which ones are not) and what are some of the characteristics of these individuals. This has provided us with important information for future developments of the program that could eventually be personalized to different types of adolescents.

Because there is some evidence that boys and girls may respond differently to different types of preventive interventions (Reivich, 1996), we also tested for potential sex differences in response to the intervention. Results showed that females had higher mean cortisol level at baseline compared to males, a finding consistent with a study showing higher morning salivary cortisol levels in mid-postpubertal girls when compared to mid-postpubertal boys (Netherton et al., 2004). Besides this sex differences in basal cortisol levels, males and females did not otherwise show distinct patterns of cortisol change following the intervention, neither did they differ on the individual characteristics modulating the impact of our program on cortisol change over time (such as anger) nor on the subsequent link to depressive symptoms.

Contrary to other prevention programs developed for stress that tap mostly on cognitive appraisal and on coping processes, the *DeStress for Success Program* is based on contemporary psychoneuroendocrine human data obtained in the last 35 years. In the program, adolescents are trained to recognize the four characteristics of a situation that have been shown to lead to a physiological stress response (the NUTS characteristics) and they also learn to contextualize these characteristics. They learn how to recognize the body's response to stress and how to get rid of the energy that is mobilized in response to stress. Finally, they learn the power of social support and they understand that sometimes, the same person that can give you social support can also give you social pressure. Issues such as bullying and peer pressure are discussed with the teenagers in order to allow them to recognize members of their community that can provide them with social support without the costs of social pressure.

To our knowledge, this is the first prevention program on stress that taps on these contemporary issues of psychoneuroendocrine research and the results of our study show that transferring scientific knowledge from the laboratory to the classroom can have significant positive effects on both cortisol levels and depressive symptoms in those adolescents who suffer the most during the transition to high school.

Although the present study showed the efficacy of the *DeStress for Success Program* at decreasing cortisol levels and depressive symptoms in adolescents with high levels of anger, it is not without limitations. First, adolescents of different schools were assigned to the two conditions and consequently, it could be argued that the effects we have observed are due to the school environment more than to the effects of the intervention. Although this could be possible, the results obtained in the same school when we split adolescents based on levels of anger can hardly be interpreted as a school effect. The second limitation concerns the lack of an attention control group. Contrary to no-intervention or wait-list control groups, attention control groups are conditions that are similar in structure to the prevention

program but that focus participants on various activities without including elements of the prevention program. Attention control groups are usually employed to control for extraneous group factors (e.g., adult attention, social support and group cohesion) that could otherwise impact on intervention effects. Due to limitations in personnel, we were not able to create an attention control group in the Control School and it is thus possible that the lack of changes in cortisol levels and depressive symptomatology observed in this group are due to the absence of stimulation that was induced by the *DeStress for Success Program*. Third, the follow-up period was not very long and consequently, it is possible that the positive effects of the program in adolescents with high levels of anger disappear over time. Future studies should assess the long-term effects (6 months and more) of the program in order to test for this. Finally, cortisol levels were obtained at different hours of the day in the two schools, and adolescents from the two schools had dramatically different awakening time due to differences in school start time. Although we statistically controlled for the differences in sampling times for cortisol levels while analyzing the effects of the program in the Intervention School, this is a limitation that is induced by the type of field study performed. Indeed, in order to be able to perform this large study in two Montreal high schools, we had to follow the decisions of the school directors as to when to test the adolescents, which led us to end up with different times of testing for cortisol levels. Yet, before starting the study, we did not think of choosing two high schools having similar start time and this difference between schools had a significant impact on adolescents' mood in the school that started early in the morning. Future studies should be aware of this important fact and control for this in order to prevent potential awakening time effects on cortisol levels.

The findings from this study carry important implications for adolescents and people working with them as they show that adolescents are receptive to scientific knowledge of stress being transferred to them and that this type of educational program leads to a significant decrease in cortisol levels in adolescents who make the transition to high schools with a high level of anger. Given the negative effects of chronic production of cortisol levels on the developing brain (Lupien et al., 2009), we believe that the development of prevention programs for stress in adolescents will give us a unique window of opportunity to modify developmental trajectories and help our teenagers develop resilience instead of stress.

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