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Stress and Obesity in Childhood

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All happy families are alike; each unhappy family is unhappy in its own way.

From *Anna Karenina* by Leo Tolstoy

Abstract

Childhood obesity is a serious health problem and prevalence increases dramatically around the world, including Sweden. The aim of the current thesis was to examine parents' and children's stress in relation to childhood obesity. Parenting stress, social support, parental worries, and serious life events, as well as children's temperament, self-esteem, body dissatisfaction, saliva cortisol, weight and height were measured to estimate stress and the relation between stress and childhood obesity.

Data was collected as part of the cohort project All Babies in Southeast Sweden (ABIS) which main aim is to understand the causes of Type 1 Diabetes. All 21700 children born between October 1997 and October 1999 in Southeast Sweden and their parents were invited to participate and questionnaires were completed for 16070 children at birth. Questionnaires were then collected at follow-ups at 1 year (*N*=11078), at 2-3 years (*N*=8803), at 5-6 years (*N*=7443), and at 8 years (*N*=3959).

The main findings were a relation between parents' psychological stress and lower self-esteem of children, a relation between parenting stress and higher cortisol levels of children, and a relation between children's body dissatisfaction and lower self-esteem. Another main finding was a relation between cumulative psychological stress and an increased prevalence of childhood obesity. The current thesis summarized these results, found good validity of the instruments, and the analyses did not indicate any systematic attrition due to stress.

It is concluded that the psychological variables reported by parents can be used as proxies for children's experience of stress in epidemiological studies such as ABIS, and that psychological stress seems to be a contributing factor in childhood obesity. This relation needs to be studied further in order to better understand and intervene in the current epidemic of childhood obesity. These findings may also help to better examine if psychological stress and childhood obesity are contributing factors in the etiology of Type 1 Diabetes.

Original publications

Paper I Koch, F. S., & Sepa, A. Parenting stress over time and children's self-esteem at age 8. *Manuscript submitted.*

Paper II Koch, F. S., Ludvigsson, J., & Sepa, A. Parents' psychological stress over time may affect children's cortisol at age 8. *Manuscript submitted.*

Paper III Koch, F. S., Ludvigsson, J., & Sepa, A. (2008). Body dissatisfaction measured with a figure preference task and self-esteem in 8 year old children - a study within the ABIS-project. *Clinical Medicine: Pediatrics*.

Paper IV Koch, F. S., Sepa, A., & Ludvigsson, J. (2008). Psychological Stress and Obesity. *Journal of Pediatrics, 153*(6).

Errata Paper III and Paper IV in the appendix

Contents

Figures and Tables

Stress and Obesity in Childhood

The concept of stress has been applied in both psychological and physiological contexts. Taken at face value stress is a relevant concept for both psychological and medical research but the definitions need to be considered carefully, in particular when comparing the concept across disciplines. In psychology and medicine the concept labeled stress has generated a vast amount of research but in both disciplines different approaches have been used to study stress and a careful consideration of what stress actually entails is needed.

In the current thesis an attempt was made to measure parents' psychological stress and to relate this stress to their children's psychological stress in an epidemiological cohort study. Psychological measures are discussed for the validity, consistency, and correlations to relevant constructs. Furthermore, children's weight and height are examined in order to determine childhood obesity in relation to the psychological variables. Finally, psychological stress is examined as a possible contributing factor in childhood obesity.

The current thesis was part of the All Babies in Southeast Sweden - project (ABIS), which aims to study causes of Type 1 Diabetes and other chronic child diseases by following a general population cohort from birth to adolescence. At the beginning the aim of the current doctoral

work was to examine the relation between psychological stress and childhood obesity and to test the hypothesis that psychological stress and childhood obesity are contributing factors in the etiology of Type 1 Diabetes. This hypothesis is introduced briefly, in order to give some background to the current thesis and point to future research, but the focus of the current thesis is stress and obesity in childhood.

Stress

Monroe (2008) argued that historically three different approaches to study stress have been taken: a stimulus, a response and an interactive approach. A stimulus approach assumed that certain environmental events have more or less the same impact on an individual and observations of these events could be used as a measure of stress. In a response approach the activation and reactions of specific physiological systems was measured and defined as stress. And the interactive approach emphasized that stress is an interactive, dynamical concept that includes the environment, the physiological and behavioral responses, and their interactions over time. In order to capture this third concept psychological approaches used the concept of psychological appraisal and physiological approaches used the concept of allostasis.

Psychological approaches that examined stress recognized that every person constructs his or her own understanding of the environment and the self. For example, Lazarus (1999/2006) suggested that a person evaluates the significance for the well-being of the self for

each situation and defined appraisal as the evaluative process by which each situation becomes meaningful for a person. Hence, stress relates to a possible threat that is appraised as an actual threat to the well-being of the self and impacts behavioral and physical responses. Vulnerability, coping strategies, and previous experiences further impact how situations are appraised and dealt with. Psychological stress is defined by taking the environment, physiological and behavioral responses, and their interactions over time into account as well as the meaning constructed by each individual.

Homeostasis and allostasis have often been used to explain how physiological systems can adapt to changing demands in order to support viability and survival of an organism (Gunnar & Quevedo, 2007; McEwen & Wingfield, 2003; Monroe, 2008). Homeostasis refers to regulations of physiological systems that are important for survival, such as body temperature and pH balance, by ensuring that these parameters are within the necessary limits. Hence, homeostasis refers to regulatory processes that ensure stability of core physiological system. Allostasis refers to regulatory systems in a broader, more encompassing context. In order to achieve homeostasis of core systems broader physiological systems adapt to changes in the environment in such a way that ensure homeostasis is possible. Taking the heart as an example, physiological changes in the muscles of the heart allow the heart to beat in a constant rhythm, supplying the body with blood. Changes in demands for blood supply, for example when one starts to run, influences the parameters controlling the heart rate and the heart rate is then adjusted to the new

demands, supplying the body with more blood. Hence, in this simplified example changes in heart rate, allostasis, ensure stability of body temperature and pH balance, homeostasis. Allostatic load refers to the prolong activation of systems that adapt to environmental demands and relates to costs or damages if the processes are maintained over a long period of time. Hence, time is a very relevant factor in stress, as short term adaptations are need for survival, whereas the same adaptations maintained over a longer time can be harmful for the individual.

Psychological stress

Different aspects of psychological stress may overlap but could be broadly categorized as emotional (feelings of sadness, depression, anxiety, shame or guilt), social (impaired relationships to parents, siblings, class mates, teachers), cognitive (impairment of cognitive functions, language disabilities / difficulties, academic failure), and environmental (loud or constant noise) stress. As pointed out the individual's appraisal of a situation and psychological resources and vulnerabilities are important in estimating stress for each person. In order to capture some of these aspects of psychological stress various instruments and methodologies have been developed. In epidemiological studies several instruments can be used to measure individual experience of psychological stress, some of which have been used in the current thesis. These are parenting stress, social support, parental worries, and serious life events. Psychological resources that

relate to psychological stress can for example be found in self-esteem and temperament. These instruments are discussed below.

Psychological stress is important for mental and physical health. For example serious life events (Coddington, 1972b) have been used to measure psychological stress and have been related to mental health problems, such as depression and anxiety (Luby, Belden, & Spitznagel, 2006). Other findings suggested serious life events may play a part in the etiology of chronic illnesses, such as diabetes (Sepa, Frodi, & Ludvigsson, 2005; Thernlund et al., 1995).

Physiological stress

Physiological correlates of psychological stress mainly stem from actions or reactions in the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis (HPA axis)(Charmandari, Tsigos, & Chrousos, 2005; Dickerson & Kemeny, 2004; Kudielka, Buske-Kirschbaum, Hellhammer, & Kirschbaum, 2004). These physiological stress response systems which evolved to cope with short term, transient stress, may cause health problems when activated under severely stressful circumstances or constantly activated under chronic stressful circumstances. Findings suggested that the HPA axis is calibrated early in life, during pregnancy and in childhood, in relation to experiences of stress and in relation to how children are helped to cope with stress (Flinn, 2006; Gunnar & Donzella, 2002). It is difficult to assess the signaling hormones (mainly corticotropin-releasing hormone, arginine

vasopressin and adrenocorticotropic hormone) involved in the cascading activation along the HPA axis. However, activation of the HPA axis results in cortisol (in humans) being released from the adrenal gland into the circulating blood and cortisol levels can often be used in studies that examine physiological stress. Among other functions, cortisol works probably as a feedback hormone that down-regulates the stress response and is involved in recovery after an acute stress response (Gunnar & Donzella).

Children's psychological stress

A theoretical framework for children's sensitivity to parental moods can be found within attachment theory. Within this theory it has been established that children need to maintain proximity to their caregiver for physical survival (Bowlby, 1958) and as a secure base (Ainsworth, Blehar, Waters, & Wall, 1978), and therefore are very sensitive to parental behavior and moods (Main, 1990). Infants' cortisol levels are elevated in relation to low maternal responsiveness (e.g., Blair et al., 2008; Mörelius, Nelson, & Gustafsson, 2007; Pendry & Adam, 2007) indicating a stressful experience of the infant due to impaired mother-infant interactions. Family climates and families' social environment continue to be important for children during development (e.g., Essex, Klein, Cho, & Kalin, 2002; Repetti, Taylor, & Seeman, 2002). Due to parents' experience of stress, children get less attention, communication suffers, and interaction becomes less positive.

Cumulative stress

When measuring stress in one domain at a time, other factors, which could compensate for or exacerbate the stress measured, may be missed (Östberg & Hagekull, 2000). Especially simultaneous exposure to stress in several domains may be seen as a marker of the stress experienced in the family, and presumably affect the child (Repetti, Taylor, & Seeman, 2002; Wekerle, Wall, Leung, & Trocme, 2007). The effect of psychological stress may be cumulative in as much that vulnerability increases not just with the severity of stress in each domain but also with the number of domains stress is experienced in (Appleyard, Egeland, van Dulmen, & Sroufe, 2005).

Obesity

It is established that excessive body fat is related to risk of diseases, such as coronary heart diseases and stroke to name a few. Several methods have been developed to measure body fat. The most reliable methods are invasive such as Magnetic Resonance Imaging, Computerized Tomography, or Dual-energy X-Ray Absorptiometry (Lobstein, Baur, & Uauy, 2004). These are expensive methods, difficult to use for children and not feasible in large scale epidemiological studies. Hence, methods have been developed to estimate body fat that are non-invasive and easy to use. They are based on measurements or ratios of different body parts. Weight and height are easy to assess, though are usually more accurate if measured by trained personnel compared to self-reports. Body mass

index (BMI = kg/m^2) is a common weight to height ratio for which cut-off values based on reference populations are available and established. WHO (WHO-Report, 2000) defines BMI between 25 and 30 as overweight and BMI ≥ 30 as obesity. Reference values for overweight and obesity in childhood need to be adjusted for age and gender (Cole, Bellizzi, Flegal, & Dietz, 2000). BMI is a reliable indicator of body fat as assessed by the Dual-energy X-Ray Absorptiometry method (Lazarus, Baur, Webb, & Blyth, 1996; Sardinha, Going, Teixeira, & Lohman, 1999). Using BMI, some children with overweight or obesity will be falsely classified as normal weight, but few children will be falsely classified as being overweight when they are actually normal weight. BMI does not work well for particular short or tall children, nor for children who have an unusual body fat distribution or highly developed muscles (Lobstein et al, 2004). Waist circumference is another measure which correlates well with body fat in children, in particular central adiposity, (Goran, Gower, Treuth, & Nagy, 1998; Taylor, Jones, Williams, & Goulding, 2000), but reference values are not yet established (Lobstein et al). BMI and waist circumference may not be good predictors of body fat in all populations as some populations have a different body fat distributions (e.g., Asian Indians: Dudeja et al., 2001; Polynesians: Swinburn, Ley, Carmichael, & Plank, 1999), but are well-established in European / Caucasian populations.

In the last decades a dramatic increase in childhood obesity has been observed in most countries around the world (Lobstein, Baur, & Uauy, 2004; WHO-Report, 2000), including Sweden (Mårild et al., 2004).

Childhood obesity has thus raised major concerns regarding children's health as children with obesity have more health problems and commonly face prejudice or stigmatization. Furthermore, the predictions are that childhood obesity is a strong indicator for health problems later in life (Lobstein et al; WHO-Report).

Lobstein et al (2004) argue that the only feasible option to tackle the world wide epidemic of obesity (WHO-Report, 2000), in particular in children, is to prevent children to become obese. In a comprehensive review (Maes, Neale, & Eaves, 1997) the genetic contribution was estimated at about 50 %. It has to be stressed that how genes are expressed depends on the interaction between genes and environment and thus the focus should be on creating an environment that is not obesogenic friendly, that is all relevant factors interact in such a way that they do not support the development of childhood obesity. Hence, understanding of how environmental factors interact with expressions of genes to create phenotypes that lead to childhood obesity is important in solving the obesity epidemic crises. Psychological stress may contribute to childhood obesity by creating or supporting the obesogenic environment for children.

Psychological stress and obesity in childhood

In a recent review (Mietus-Snyder & Lustig, 2008), it was argued that childhood obesity and experience of stress are closely related. As food intake is paramount for survival, strong reward systems have evolved

that are deeply embedded in the central nervous system, involving structures in the amygdala and hypothalamus. These structures promote a "starvation response" when a person lacks food and drive a person to eat. With high percentage of body fat, hormonal signaling pathways, involving leptin and insulin, can also trigger a starvation response, in particular in relation to physiological stress with elevated levels of cortisol.

Some epidemiological studies have looked at the relation between childhood obesity and psychological stress or related concepts. Mellbin and Vuille (Mellbin & Vuille, 1989a, 1989b) summarized school health records, which included data on health as well as social problems in one stress score and summarized teacher reports on behavior problems in another stress score for children 7 to 13 years old. They found that stress scores were significantly higher in children who increased at least 15 % in relative weight compared to children who did not increase in relative weight. Lissau and Sørensen (1994) also looked at school nurse and teacher reports of pupils. They found that children who were classified as dirty and neglected or who had no support from home when they were 10 years old had a significantly higher odds ratio for obesity by the age of 20 years.

Problems with family functioning have been related to overweight and obesity for children (Gundersen, Lohman, Garasky, Stewart, & Eisenmann, 2008; Wilkins, Kendrick, Stitt, Stinett, & Hammarlund, 1998; Zeller et al., 2007) and adolescents (Mellin, Neumark-Sztainer, Story, Ireland, & Resnick, 2002) but have not been confirmed in all studies

(Gibson et al., 2007; O'Callaghan, Williams, Andersen, Bor, & Najman, 1997). Wilkins et al (1998) compared family functioning between 10 children with overweight or obesity and 25 children with normal weight and found a trend for worse family functioning in children with overweight or obesity. In an epidemiological study Mellin et al (2002) found a relation between better parent-adolescent relationships and lower frequencies of behavioral and psychosocial risk factors associated with overweight. O'Callaghan and colleagues (1997) tried to identify longitudinal predictors of obesity for 5 year old children. Mothers reported, among other factors, on their children's behavior and their own depression and anxiety but no significant relation between these factors and childhood obesity was found. Gibson et al (2007) assessed maternal depression, family functioning, parenting discipline styles, life events, and mothers' self-esteem but did not find any significant relation between these factors and children's weight status cross-sectionally. On the other hand, Zeller et al (2007) did find differences in maternal distress in a matched control study for children with and without obesity. They also found that the family climate as perceived by the mother was significantly worse in families of children with obesity. Gundersen et al (2008) examined the relation between maternal stress and childhood obesity in low income families in the USA. Due to poverty, food was not readily available in some of these families, and it was found that maternal stress related to children's obesity for children age 3 to age 10, if food was readily available in the household. In households where food was not readily available this relation was not

found. This finding supports the idea that psychological stress may be related to obesity in obesogenic environments.

Golan, Fainaru, and Weizman (1998) examined the effects of intervention strategies on reduction of weight for children with obesity. They compared an intervention strategy that focused only on the child (the common method) with an intervention strategy that focused on the parents as the agents of change in dietary behavior of the child. They found that targeting the parents had a significant better effect on children's weight reduction than targeting the child. This highlights the importance of parents shaping the environment for children when it comes to food habits.

Type 1 diabetes

Type 1 diabetes is the result of an autoimmune process that destroys the insulin producing beta-cells in the islets of Langerhans in the pancreas. The severity of the autoimmune process correlates with concentrations of autoantibodies against Tyrosine Phosphatase (IA-2) and against Glutamic Acid Decarboxylase (GAD), which can be measured in blood. Hence, higher concentration of IA-2 autoantibodies and GAD autoantibodies indicate a higher risk for development of Type 1 diabetes (T1D). According to the beta-cell stress hypothesis (Ludvigsson, 2006) psychological stress and obesity (among other factors) lead to decreased insulin sensitivity and / or increased demand for insulin in the body. Thus, the insulin producing beta-cells in the pancreas are under pressure

to produce sufficient insulin and are more vulnerable to be attacked and destroyed in an autoimmune process. Therefore, both psychological stress and higher than average BMI have been suggested as risk factors for development of T1D. Parents' report of serious life events was related to higher levels of autoantibodies involved in the destruction of beta-cells (Sepa, Frodi, & Ludvigsson, 2005; Sepa, Wahlberg, Vaarala, Frodi, & Ludvigsson, 2005). Furthermore, children recently diagnosed with T1D reported serious life events more often than control children (Hägglöf, Blom, Dahlquist, Lönnberg, & Sahlin, 1991; Thernlund et al., 1995). Accelerated growth (Knip et al., 2008) and obesity (Kibirige, Metcalf, Renuka, & Wilkin, 2003; Viner, Hindmarsh, Taylor, & Cole, 2008) have been related to the increased prevalence of T1D and a younger age at debut for T1D. Incidence of T1D is increasing in Sweden and world wide and environmental factors need to be considered as possible contributing factors. Epidemiological studies may help to understand these relations but it needs to be clarified how psychological stress can be measured concerning children in these studies. Furthermore, if psychological stress and obesity are related their interaction should be taken into account when studying the relation to etiology of T1D.

Psychological measurements

In the current thesis parenting stress (Abidin, 1990; Östberg, Hagekull, & Wettergren, 1997), social support (Crnic, Greenberg, Ragozin, Robinson, & Basham, 1983; Raikes & Thompson, 2005; Östberg & Hagekull, 2000),

parental worries (*American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders*, 1994) and serious life events (Coddington, 1972a, 1972b; Johnston, Steele, Herrera, & Phipps, 2003; Williamson et al., 2003) were used to measure parents' psychological stress.

Parenting stress describes parents' experience of stress in the domain of parenting (Abidin, 1990; Östberg, Hagekull, & Wettergren, 1997). Abidin and coworkers developed the parenting stress index to assess stressors in the child's, mother's or situational / demographic domains of the parent-child system (e.g., Abidin, 1982). Hasket and coworkers (Haskett, Ahern, Ward, & Allaire, 2006) validated a 36 item short form of the parenting stress index and identified two factors, one for the parent domain (termed personal distress) and one for the child domain (termed childrearing stress). Even though the two domains were correlated ($r = .58$), they argued that each domain represented a distinct construct. Focusing on the parent domain of the parent-child system Östberg and coworkers (1997) translated the parenting stress index (Form 6, the then current version) to Swedish but questioned the coherence of the American version because some items loaded, according the manual (Abidin, 1990), better on other factors and subscales correlated highly with each other. Östberg and coworkers added some new items, deleted some of the original items, and relocated some items to other subscales and finally proposed a 34 items version, consisting of 5 subscales. Based on factor analysis they argued that these subscales are distinct but all belong to the parent domain of the parenting stress construct. They

argued that the proposed version measures a higher order parenting stress construct that influences all subscales, but that each subscale can be used to measure specific aspects of parenting stress. For example, aspects of social support can be further studied by relating to the subscale of social isolation of parenting stress. Östberg et al point to a construct validity by showing a relation between parenting stress and daily hassles. Furthermore, Östberg et al show a relation of parenting stress scores and stress rated by a psychologist who observed parent-child play. Test-retest validity has been reported frequently and Östberg, Hagekull and Hagelin (2007) report a stability for parenting stress over a six year period.

Social support works as a buffer in psychological stressful situations (Cobb, 1976) but social relationships can be impaired by as well as be the reason for psychological stress, for adults (Cohen & Wills, 1985) and children (Caldwell, Rudolph, Troop-Gordon, & Kim, 2004). Crnic et al (1983) assessed social support in 105 mothers to preterm and full-term infants. They differentiated between intimate relationships (spouse / partner) support, friendship support and neighborhood / community support as different kinds of social support with together nine items. Each domain was confirmed in a factor analysis and internal consistency was between .50 and .69 for each social support domain. Mothers who were satisfied with their social support were more satisfied with their general life situation and with parenting. Contrary to Cobb, social support was not found to buffer effects of stress experienced by parents. Instead, social support had beneficial effects on mothers'

attitudes and mothers' behavior towards the child. Crnic et al argued that the relation found between social support and positive behavior towards the child, as measured by reciprocity and mutual gratification, showed that a functional social system of the mother has indirect beneficial effects for the child. When the child grows older the child may benefit directly from the parents social network but until then parents mediate the positive effects. Östberg et al (1997) used the social support measured in its Swedish version with a quantitative and qualitative part. First, parents were asked to quantify for example "How many times do you meet your friends/relatives and/or keep in contact via telephone per week?". Then parents were asked how satisfied they were with this situation. They identified a social network and an emotional support domain as part of social support, when quantitative and qualitative items were pooled. Each domain had an internal consistency of >.86. Both domains related significantly to parenting stress (Östberg, Hagekull, & Wettergren, 1997). In a later study (Östberg & Hagekull, 2000) they used only the quantitative part of social support in a structural equation model and found that lack of social support was related to parenting stress and to a latent variable termed *domestic work load*. This social support measure was found to be stable over a two year period for high stress parents of children with developmental delay (Guralnick, Hammond, Connor, & Neville, 2006).

Excessive worries about the offspring's health is part of the criteria for anxiety disorder (*American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders*, 1994) and worries are included in

various anxiety scales, whereas the Penn State Worry Questionnaire measures worries as a single domain (Meyer, Miller, Metzger, & Borkovec, 1990) that could be a construct independent of anxiety and depression (Brown, Antony, & Barlow, 1992). In a reexamination of an instrument call the *State Trait Anxiety Inventory* it was found that items about worries were helpful in discriminating between anxiety and depression (Bieling, Antony, & Swinson, 1998). Adults with anxiety or depression were high in negative affects but adults with anxiety, unlike adults with depression worried a lot as well. Excessive maternal worries about children's health may be associated with an insecure-dismissive attachment pattern (Main, Goldwyn, & Hesse, 2001). Studies have shown a relation between parental anxiety or depression and problematic parental practices. Some parents may be overinvolved and overprotective because they worry too much about negative events (Bayer, Sanson, & Hemphill, 2006). Bayer at al (2006) found that overinvolved / overprotective parenting was related to children's internalizing problems.

Stressful life events, or as called in ABIS *serious life events*, have commonly been assessed by self-reported checklists (social readjustment rating scale by Holmes and Rahe, 1967). Coddington applied this to children, using professionals (1972a) or parents and adolescents (1972b) as informants. Monroe (2008) points out that checklists generally fail to correspond to interview results. For example, Lewinsohn, Rohde, and Gau (2003) compared data reported by young adults for stressful life events collected by checklist and by interview technique. They found a

correspondence of 67.5 % for events experienced by the self (i.e. the participant) and only 19.7 % for events experienced by significant others. Most reported events concerned significant others and on overall correspondence was less than 50 %. Duggal et al (2000) found that serious life events could predict depression in adolescents, irrespective if an interview method or an self-report method was used. Duggal et al concluded that both methods are feasible but need to be used according to the purpose. Whereas a self-reported checklist may be better to assess a general level of stress, the interview technique should be used to identify experiences of particular life events.

Temperament, low self-esteem and body dissatisfaction are not direct measures of psychological stress. Nevertheless, Belsky (1984) suggested that child characteristics influence parent-child interactions and may contribute to parenting stress. Children's temperament may increase parents psychological stress (Pesonen et al., 2008). Low self-esteem may increases vulnerability to psychological stress (Bovier, Chamot, & Perneger, 2004; Pyszczynski, Solomon, Greenberg, Arndt, & Schimel, 2004) and body dissatisfaction may increase vulnerability to depression and low self-esteem (Paxton, Neumark-Sztainer, Hannan, & Eisenberg, 2006).

Examining temperament, Lee and Bates (1985) created and validated the 24-month version of the Infant Characteristics Questionnaire and found a difficultness dimension that was stable for toddlers from 6 to 24 month. They related this scale to home observations and found that children, who had a more fuzzy-difficult temperament, as perceived by

their mothers, resisted their mothers' control attempts more and had more conflict with their mothers. Over a 5 year period Pesonen et al (2008) found that maternal stress increased in relation to children's difficult temperament. They also found that maternal stress contributed to children's development of a difficult temperament. In a review article (Compas, Connor-Smith, & Jaser, 2004) it was concluded that children's temperament could be linked to their vulnerability to depression. Furthermore, psychological stress moderated how temperament contributed to depression and temperament moderated how psychological stress contributed to depression.

Low self-esteem is not a direct measure of stress but adolescents with low self-esteem may show higher tendencies for suicide (Evans, Hawton, & Rodham, 2004) and being a victim of bullying (Salmivalli, Kaukiainen, Kaistaniemi, & Lagerspetz, 1999). Furthermore, high self-esteem may protect against psychological stress (Bovier, Chamot, & Perneger, 2004) and anxiety (Pyszczynski, Solomon, Greenberg, Arndt, & Schimel, 2004). For girls low self-esteem was related to problematic eating attitudes and eating pathologies (Button, Loan, Davies, & Sonuga-Barke, 1997). Hence, children's self-esteem may be a relevant aspect to measure and take into account, when studying the relation between psychological stress and obesity.

Ouvinen-Birgerstam (1985) developed and validated a Swedish instrument to assess children's self-esteem from 8 years of age. Henricsson and Rydell (2004) used this instrument to examine teacher-child relationships, but referred to the instrument as a measure of self-

perception. They found that children with lower self-esteem or less positive self-perception, in their terms, had more externalizing and more teacher-child interaction problems. Jutengren and Palmèrus (2007) examined the conflict style between parents and adolescents and found that adolescents with good self-esteem or a positive self-perception were more likely to have parents who used an authoritative parenting style. As opposed to authoritarian, indulgent, and neglectful parenting, authoritative parenting is characterized by warmth and mutual respect. Wadsby, Svedin, and Sydsjö (2007) found lower self-esteem in children to psychosocial at risk mothers compared to a reference group. Furthermore, they found that lower self-esteem was related to more emotional / behavioral problems and more occurrences of life events. As for the relation between self-esteem and obesity Renman and coworkers (Renman, Engström, Silfverdal, & Åman, 1999) did not find a difference in self-esteem for children with and without obesity.

Low self-esteem, though not measured with Ouvinens-Birgerstams instrument, was related to body dissatisfaction in adolescents (Paxton, Neumark-Sztainer, Hannan, & Eisenberg, 2006; Tiggemann, 2005) and 8 to 10 year old children (McCabe & Ricciardelli, 2003). Body dissatisfaction constitutes a risk factor for dieting (Truby & Paxton, 2002), and further eating disturbances (Ricciardelli & McCabe, 2001). In light of the increase of childhood obesity a growing number of children may experience psychological stress as they realize they are not matching the ideal of society for how one or one's body should look like. The figure preference task (Collins, 1991) is one instrument that assesses

body dissatisfaction but the literature is not clear about if the figure preference task is meaningful in children aged 8 to 10 years (Smolak, 2004) and if it is related to self-esteem (Furnham, Badmin, & Sneade, 2002; Tiggemann, 2005; Tiggemann & Wilson-Barrett, 1998).

Hypotheses

Current thesis

- Parents' experience of psychological stress can be used as a proxy for children's experience of stress. Validity of psychological measurements are examined.

- Psychological stress is a contributing factor in the development of childhood obesity.

The different papers have more detailed hypotheses.

Paper I Parents' psychological stress, as measured by parenting stress, serious life events, dissatisfaction with social support and parental worries, relates to children's self-esteem.

Paper II Higher parenting stress, parents' experience of serious life events, and lower self-esteem among children relate to higher levels of children's cortisol before a mild stressor is administered and to an increase in cortisol, as a reaction to the mild stressor.

Paper III
- Body dissatisfaction, measured with the figure preference task, relates to body measurements, such as weight, body mass index, and waist circumference, but less to height.
- Body dissatisfaction relates to lower self-esteem.

Paper IV Children exposed to psychological stress, as measured by parenting stress, dissatisfaction with social support, parental worries and serious life events, in the family are more likely to be classified as obese.

Method

The inclusion criterion for ABIS was that the child was born in southeast Sweden between 1st October 1997 and 31st October 1999. During this time about 21700 children were born in the region. Children were included in ABIS after their parents gave informed consent and a questionnaire and / or biological samples were delivered. A total of 17055 children were included in ABIS but only 16070 questionnaires were delivered at birth. Subsequently, parents completed questionnaires when the child was 1 year, 2-3 years, 5-6 years, and 8 years old (referred to as age 1, age 2, age 5, and age 8, respectively).

Material

The questionnaires included items about psychological stress, environmental factors and health issues concerning parents and their child. Up to age 5, questionnaires were given to the accompanying parent when taking the child to the regular health care check-ups at the local well-child clinic (used by > 99% of Swedish parents). The parents filled out the questionnaires either during the visit at the clinic or later at home. No reminders were used. At age 8, two questionnaires (a parent and a child version) were sent home to the families. The current thesis was based on questionnaire data provided at birth (N = 16070), at age 1 (N = 11078), at age 2 (N = 8803), at age 5 (N = 7443), and at age 8 (N = 3959) by the parents as well as at age 8 (N = 3837) by the children.

All participants who provided data at birth were invited to participate at all follow-ups. Questionnaire data in ABIS was available for 16431 children because some parents decided to fill out ABIS questionnaires only for follow-ups.

At birth parents reported their *personnummer* (Swedish social security number) and their children's date of birth. At follow-ups children where identified by their unique ABIS alias and parents provided their own and their children's personnummer. In spring of 2008, after data was collected at age 8, the accuracy of the ABIS aliases was checked by matching parents' and children's personnummer and children's date of birth with ABIS aliases. 72 ABIS aliases needed to be changed for at least one follow-up, that is the ABIS alias referred to another child for at least one of the follow-ups. In most cases two ABIS aliases were confused between two children. In some cases two different ABIS aliases referred to only one child and the data could be completed by merging the data for that child. None of these cases were twins but confusion of ABIS aliases between two twins cannot be ruled out if twins had the same gender. During this process it was possible to complete some missing data (for gender and date of birth) and to check some contradicting data (e.g., verify if a child was actually a boy or a girl). Even though some of the data were not matched correctly before the ABIS aliases were checked, the error margin was surprisingly low: < .01 % (92 of 31152 questionnaires collected at follow-up that could be confirmed). Personnummer were not available for all cases and hence 131 cases could not be confirmed.

Participants

The cohort participating in ABIS consisted in total of 16431 children. 48.1 % (*n* = 7880) were girls and 51.9 % (*n* = 8486) were boys (missing data: *n* = 65). 380 children were twins and 324 were non-twin siblings. At each follow-up the age of the children varied by some month. The mean age of children was at age 1: 12.0 month (SD = 1.2), age 2: 33.1 month (*SD* = 3.6), at age 5: 64.5 month (*SD* = 3.5), and at age 8: 95.0 month (*SD* = 3.9).

Table 1 shows parents' level of education when their child was born. Table 2 shows prevalence of custody status and number of siblings for children in ABIS with regard to follow-up. Mean age when their child was born was for mothers 29.6 (*SD* = 4.6) years and fathers 32.1 (*SD* = 5.4) years. 6.6 % of mothers (n = 1060, missing data n = 426) and 7.2 % of fathers (n = 1152, missing data n = 470) were born outside Sweden. Questionnaires were usually answered by the mothers rather than the fathers (age 1: 94.6 %, age 2: 96.3 %, age 5: 91.2 %, and age 8: 89.0 %).

Table 1 *Parents' level of education when their child was born.*

	Education			
	Mothers		Fathers	
	N	%	N	%
9 years of school	1375	8.6	2140	13.6
12 years of school	9517	59.7	9713	61.8
≥ 1 year at university	5062	31.7	3863	24.6

Table 2 *Prevalence of custody status and number of siblings for follow-ups age 2 through to age 8.*

	Follow-up					
	Age 2		Age 5		Age 8	
	N	%	N	%	N	%
Custody						
Mother and Father	8288	94.7	6622	91.9	3491	89.9
Single parent	256	2.9	222	3.1	108	2.8
Joint custody	205	2.3	360	5.0	283	7.3
Number of Siblings						
None	1949	22.3	466	6.5	193	5.0
1-2	6104	69.9	5881	82.0	3200	82.7
≥ 3	684	7.8	827	11.5	477	12.3

Measurements

Parents filled out questionnaires that included measurements for parenting stress, social support, parental worries, serious life events, and their children's temperament at birth and at various follow-ups. An overview is shown in Table 3. Children filled out a questionnaire that included measurements for their self-esteem and body dissatisfaction at age 8. Parents reported also their children's weight and height at birth and all follow-ups, and their children's waist circumference at age 8. Saliva samples, analyzed for cortisol, were collected for some children at age 8. Furthermore, demographic data was provided by parents at all follow-ups.

Table 3 *Overview of measurements assessed in ABIS that were used in the current thesis.*

		Follow-up			
	Birth	Age 1	Age 2	Age 5	Age 8
Reported by parents					
Parenting stress		X	X	X	X
Quantity of social support				X	
Dissatisfaction with social support				X	
Parental worries			X	X	X
Serious life events	X		X	X	X
Fuzzy-difficult temperament			X		
Reported by children					
Self-esteem					X
Body dissatisfaction					X
Children's					
Weight			X	X	X
Height			X	X	X
BMI			X	X	X
Waist circumference					X
Saliva cortisol					X

Psychological measurements reported by parents

Parenting stress was assessed with the Swedish Parenting Stress Questionnaire (SPSQ; Östberg, Hagekull, & Wettergren, 1997) at age 1, age 2, age 5, and age 8. Due to space restrictions in the ABIS questionnaire at age 5 and age 8, three (a total of 23 items) of the five (a total of 34 items) original domains were used, tapping the dimensions: *incompetence* (11 items, e.g., "It is more difficult than I expected to raise a

child."), *spouse relationship problems* (5 items, e.g., "Since I became a parent I get less support than I expected from my partner."), and *role restriction* (7 items, e.g., "Since I got the child I have hardly any time for myself."), excluding the dimensions *social isolation* (7 items, e.g., "Thanks to the child I got quite a few new acquaintances.") and *health problems* (4 items, e.g., "Since I got the child I have suffered from many different infections"). On each item a 6-point Likert-type response scale was used ranging from "strongly disagree" to "strongly agree". Criterion for inclusion in the statistical analyses was that no more than 5 items of the SPSQ were unanswered. This criterion was chosen in order to include single parents (about 3% or participants at each follow up) who might not have been able to answer items of the spouse relationship problems dimension. The mean of all answered items reflected parenting stress, with higher means indicating more stress.

Social support was assessed with 10 items tapping social support at age 5 (derived from Crnic et al., 1983, and used in its Swedish form in Östberg & Hagekull, 2000). First, parents were asked to quantify for example "How many times do you meet your friends/relatives and/or keep in contact via telephone per week?". This quantitative part of the instrument is referred to as *Quantity of Social Support* but was not used in any of the papers. Categories used were "0", "1-2", "3-4", "5-6", and "more than 6". Parents were also asked how satisfied they were with their social support on a 5-point Likert-type response scale running from "very satisfied" to "very dissatisfied" for each item. This yielded a measure of *Dissatisfaction with Social Support* (in Paper IV referred to as

lack of social support), as higher means indicated more dissatisfaction. A mean representing quantity of and dissatisfaction with social support was calculated when at least 9 of the 10 items were answered, respectively.

Parental worries were assessed by six items, each describing a potential risk for the child (that the child falls seriously ill, is harmed, is going to be handicapped, is not going to develop normally, is going to be exposed to abuse, and is not going to survive) at age 2. At age 5 one item was added (i.e. that the child would get a chronic or serious disease). At age 8 six items were used (that the child falls seriously ill, is harmed, is going to be exposed to abuse, is going to die, is going to be bullied in school, and does not have any friends). For each item the parent estimated on a 6-point Likert-type response scale ranging from "very calm" to "very worried" how worried they were that their child might become affected. A mean representing parental worries was calculated if no more than 1 item was missing.

Serious life events were assessed with the following yes / no question: "Have you been exposed to something which you perceive as a serious life event [during a given time period]?". At birth the time period given was: "...during pregnancy?", at age 2 and age 5: "... since your child's birth?", and at age 8: "... the last 2 years?". Examples given at birth were: "death of a relative", "divorce". At age 2, age 5, and age 8 the previous examples were given as were the following: "serious disease in the family", "serious accident in the family", "exposure to violence", and "unemployment". At age 2, age 5, and age 8 parents could indicate what

kind of serious life events they had experienced by ticking a box next to the given examples but this data was not used in the current thesis.

Children's temperament was assessed at age 2 with the 7 items of the *Fuzzy-Difficultness* subscale of the Child Characteristics Questionnaire, adjusted and validated for 24 month old children by Lee and Bates (1985) and used in its Swedish form in Östberg and Hagekull (2000). The mean was calculated when at least 6 of the 7 items were answered and higher scores indicate a more fuzzy-difficult temperament, as perceived by parents.

Furthermore, *composite measures of psychological stress* were created in order to estimate the overall amount of stress experienced in the family, by counting the number of times a child was exposed in any of the measured domains. Exposure in a domain was defined as a mean above the 95th percentile for parenting stress, dissatisfaction with social support, or parental worries or the parent reported a serious life event. If a child was not exposed in any of the domains the score for the composite measure was 0. If a child was exposed in at least two domains the child was considered to be exposed to high stress in the family. In Paper IV three composite measures were used: The *composite measure at age 2* counted exposure to serious life events, parenting stress, and parental worries at age 2. The *composite measure at age 5* counted exposure to serious life events, parenting stress, dissatisfaction of social support, and parental worries at age 5. The *composite measure over time* counted exposure to serious life events, parenting stress, and parental worries, if children were exposed both at age 2 and at age 5 (for details see Paper

IV). In the current thesis *composite measure at age 8* is also reported and counted exposure to serious life events, parenting stress, and parental worries at age 8. At this age, exposure to parenting stress was defined as a mean ≥ 3.72 (representing the 95th percentile) and exposure to parental worries with a mean ≥ 4.55 (95th percentile).

Psychological measurements reported by children

Self-esteem of the child was assessed at age 8 with the Swedish instrument *I Think I Am* (Swedish: *Jag Tycker Jag Är*) developed and validated by Ouvinen-Birgerstam (1985). The instrument consisted of 32 items in 5 domains tapping: *Physical Characteristics* (6 items, e.g., "I have a nice face"), *Skills And Talents* (6 items, e.g., "I am good at drawing"), *Mental Well-Being* (8 items, e.g., "I get easily angry", "I am almost always happy"), *Relationship To Family* (6 items, e.g., "My parents trust me"), and *Relationships To Others* (6 items, e.g., "Other children are often mean to me"). The child agreed or disagreed with each item by ticking a box for yes or for no. For each domain the sum of negative events was calculated. Answering the item "I am almost always happy" with "no" is a negative event, as is answering "I get easily angry" with "yes".

Body dissatisfaction was assessed with the figure preference task that asked children to choose one of nine silhouettes depending on what they think their body looks like and what they want their body to look like. The silhouettes depicted a girl and a boy (about 6 to 10 years old) from being very thin to being obese (based on Collins, 1991, and

modified by Rand and Resnick, 2000). First children were asked: "What does your body look like? Cross out the one [silhouette] which looks most like you". Underneath the question were the silhouettes of the girl and the boy. This item yielded a score for the child's *perceived body size* from 1 (very thin) to 9 (obese). On the next page of the questionnaire children were asked to "Cross out [the silhouette illustrating] what you want your body to look like." followed by the silhouettes of the girl and the boy. This item yielded a score for the child's *ideal body size* from 1 (very thin) to 9 (obese). The difference between perceived and ideal body size yielded a score for *body dissatisfaction*.

Body measurements: weight, height, BMI and waist circumference

Parents reported weight, height, and waist circumference of their children and the children's body mass index (BMI = kg/m^2) was calculated. Children were classified as overweight or obese based on age and gender adjusted international standards for overweight and obesity (Cole, Bellizzi, Flegal, & Dietz, 2000) at age 2, age 5, and age 8. Internationally comparable standards for overweight and obesity in childhood were constructed by Cole et al (2000) based on samples from six different countries. Percentiles equivalent to BMI = 25 and BMI = 30 at age 18 years for boys and girls, respectively, were used to select BMI cut-off values that define overweight and obesity for children 2 to 17.5 years.

In the current thesis, some children were classified at age 8 as underweight depending on their BMI value. As cut-off for underweight

the 10th percentile within each age group was used (Boys: 7.5 years: BMI < 14.12; 8 y: 14.35; 8.5 y: 14.65; Girls: 7.5 y: 13.88; 8 y: 14.08; 8.5 y: 14.38), due to the lack of an internationally comparable standard for underweight.

Cortisol

A convenience sample of children who participated in ABIS was asked to participate in a physical activity study and to provide a blood sample. 126 children participated and were asked for saliva samples just before and 30 minutes after they provided the blood sample. 53 (46 %) were boys and mean age of the children was 7 years 10 month (*SD* = 4.7 month). Their mothers' age at their birth was 30 years 6 month (*SD* = 4.7 years). The children went to 13 different schools in a medium sized Swedish city (about 120 000 inhabitants). After obtaining informed consent from parents and children, children were asked to see their school nurse to leave saliva and blood samples, and being measured for weight and height. Instructions to children stated that they should not eat or brush their teeth that morning. Parents had received an anesthetic crème beforehand and had been asked to apply the crème on the child's arm before the child went to school. Saliva was collected before (cortisol sample 1) and after (cortisol sample 2) a venous or, if the child preferred, capillary blood sample was drawn. All venous blood samples were collected under a local anesthetic. Saliva was collected by asking children to chew on an absorbent cotton dental roll for about 2 minutes before the

blood sample was drawn. In connection with the first saliva sample collection children were asked if they had had something to eat or drink, if they had brushed their teeth, and if they had been running or cycling within the last 30 minutes. Children were also asked to rate with the Color Analogue Scale from 1 to 10 (CAS; Hicks, Von Baeyer, Spafford, Van Korlaar, & Goodenough, 2001) how afraid they were of a blood sample being drawn. After the blood sample was drawn children were asked to rate their pain with help of CAS. 30 minutes after the blood sampling the second saliva sample was collected using the same procedure as for the first sample. This time children rated with CAS how unpleasant it was to have a blood sample drawn. The exact time of day was recorded when the saliva samples were collected.

Demographic variables

Demographic variables were used to adjust various statistical relations and to identify problems with attrition. Demographic variables were, children's gender, number of siblings, custody status, parents' age at their child's birth, parents' origin, and parents' education. The way some of these variables were categorized varied between statistical analyses and between attrition analyses. Details were reported in connection with statistical models and attrition analyses in each paper. An overview of demographic variables for the whole ABIS sample is shown under participants (Table 1 and Table 2).

Ethical considerations

Parents received written and oral information and were invited to watch a video film about ABIS before they gave their consent to participate. ABIS was approved by the research ethics committees of the Faculty of Health Sciences at Linköping University, Sweden and of the Medical Faculty at Lund University, Sweden. Additional data, reported in paper II, was collected in a subsample of children participating in ABIS. Parents of these children were informed of the purpose and procedure for further data collection and asked for permission for their child to participate previous to the day of testing at their child's school. On the day of testing children were reminded that they could withdraw from the study at any time as well as not participate in certain parts (e.g., not provide a blood sample). When children seemed nervous extra care was taken to reassure them and to ask if they wanted to proceed.

Statistics

Psychological measurements were tested for internal consistency with Cronbach's alpha, and stability over time and relations between psychological measurements were tested with Pearson correlation coefficient. Serious life events was a dichotomous item and tested for relations over time with χ^2 tests. A Cronbach's alpha > .70 was considered to be acceptable and as a level of statistical significance $\alpha = .05$ was used. Details for statistical analyses concerning results presented in Paper I to Paper IV were reported there. Logistic regression

models were used to estimate the relation between composite measures and childhood obesity at age 8. Attrition analyses were performed using independent sample *t* tests and χ^2 tests.

Results

First, descriptive details about psychological stress variables reported by the parents are presented. Figure 1 shows mean, standard deviation and range for each psychological stress variable assessed and Figure 2 shows cross-sectional and longitudinal correlations between variables.

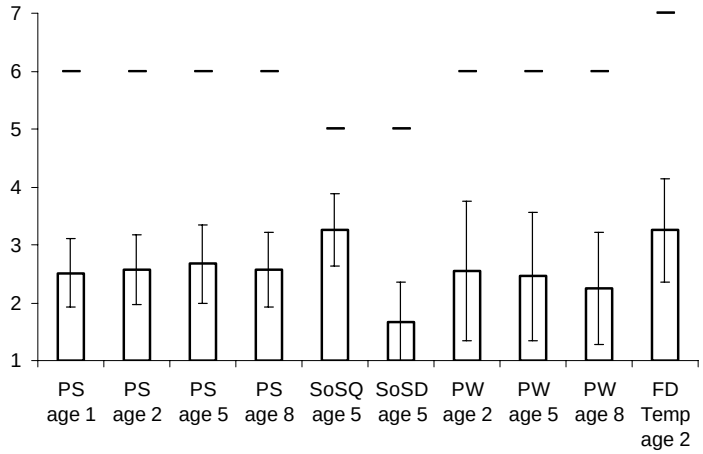

Figure 1 Means and SD for psychological measures reported by the parents. PS: Parenting stress, SoSQ: Quantity of Social Support, SoSD: Dissatisfaction with Social Support, PW: Parental Worries. All scales range from 1 to maximum shown by —.

Parenting stress at age 1 and age 2 was measured with a 34-item version and at age 5 and age 8, with a 23-item version, excluding dimensions for social isolation and health. Correlations between means based on 34 and 23 items at age 1 and age 2, respectively, were significant, age 1 and age 2: $r = .96$, $p < .001$, but means based on 23 items

were higher, age 1: mean difference = .15, $t(10736) = 75.8$, $p < .001$, and age 2: mean difference = .14, $t(8641) = 64.3$, $p < .001$. Correlations for parenting stress based on 34 or 23 items did not change between follow-ups (data not shown). Further details are shown in Table 2 of Paper I.

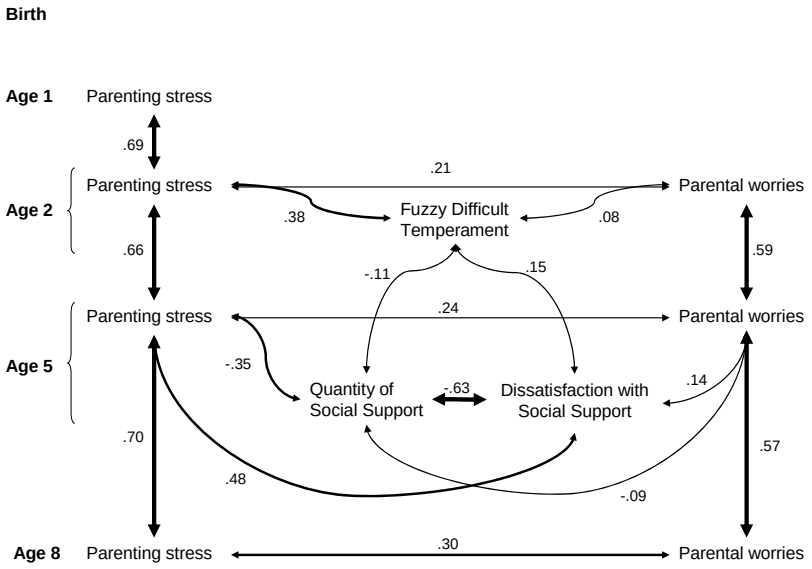

Figure 2 Pearson correlations over time and cross-sectional between psychological variables. Children's age when variables were assessed are shown to the left. For all correlations: $p < .001$.

Parenting stress and parental worries showed stability over time, as all correlations for parenting stress between follow-ups were $r > .65$ and for parental worries $r > .55$. Parental worries did not correlate well with Fuzzy-Difficult temperament of the child or Social Support measures, all

$r < .15$. Correlations between parenting stress and parental worries were higher but still all $r < .31$. Figure 2 shows details for these correlations. The only longitudinal relations between variables reported are Fuzzy-Difficult Temperament and Social Support measures, because they were not measured cross-sectionally. These correlations were $r \leq .15$. All psychological variables reported by parents had an acceptable internal consistency, as shown in Table 4.

Table 4 *Number of items and Cronbach's alpha for psychological variables.*

	N of items	Cronbach's alpha
Parenting stress age 1	34	0.88
Parenting stress age 2	34	0.89
Parenting stress age 5	23	0.88
Parenting stress age 8	23	0.87
Quantity of Social Support at age 5	10	0.81
Dissatisfaction with Social Support age 5	10	0.88
Parental worries age 2	6	0.89
Parental worries age 5	7	0.91
Parental worries age 8	7	0.86
Fuzzy-Difficult temperament age 2	7	0.83

Serious life events were assessed dichotomously and the prevalence is shown in Table 5. The question about serious life events at age 5 included the time from birth, hence all participants who reported the experience of a serious life event at age 2 should also report that at age 5. However, 379 (26.5%) parents reported a serious life event at age 2 but

not at age 5. Looking at items that did not include the same time period, reporting a serious life event increased the likelihood of reporting a serious life event later: birth and age 2, $\chi^2(1, N=8464) = 93.8$, $p < .001$, birth and age 5, $\chi^2(1, N=7157) = 52.0$, $p < .001$, birth and age 8, $\chi^2(1, N=3701) = 9.5$, $p < .01$, age 2 and age 8, $\chi^2(1, N=2932) = 25.1$, $p < .001$, and age 5 and age 8, $\chi^2(1, N=2762) = 76.4$, $p < .001$.

Table 5 *Prevalence of serious life events from birth to age 8.*

	Follow-up							
	Birth		Age 2		Age 5*		Age 8	
	N	%	N	%	N	%	N	%
Serious life event								
No	14417	90.7	6601	75.7	4694	63.7	2558	68.1
Yes	1486	9.3	2119	24.3	2670	36.3	1199	31.9

* The item used to assess serious life events at age 5 included time from birth.

Paper I

An overview of variables examined in Paper I is shown in Table 7. The self-esteem measurement was answered completely by 3446 children. 24.3 % (n = 837) of these children answered all 32 items in a positive way. A further 24.2 % (n = 833) answered only one item in a negative way. The mode was 0 items answered negatively, while the median was 2 items answered negatively and the mean was 2.34 items answered negatively. 5 % (n = 166) of the children answered 8 items or more negatively with a maximum of 25 items answered negatively. Details for domains are

shown in Table 6 and further details and correlations can be found in Table 1 of Paper I.

Table 6 *Descriptive details and Cronbach's alpha for self-esteem domains and overall score.*

	Mean	*SD*	Median	Cronbach's alpha
Self-esteem domains				
Physical Characteristics	0.21	*0.56*	0	0.42
Skills and Talents	0.58	*0.58*	0	0.38
Mental Well-Being	0.54	*0.95*	0	0.55
Relationship to Family	0.63	*0.87*	0	0.37
Relationships to Others	0.39	*0.75*	0	0.47
Self-esteem overall score	2.34	*2.63*	2	0.73

Table 7 *Variables examined in Paper I are shown in bold and marked with X. Self-esteem was the dependent variable.*

		Follow-up			
	Birth	Age 1	Age 2	Age 5	Age 8
Reported by parents					
Parenting stress		**X**	**X**	**X**	**X**
Quantity of social support				o	
Dissatisfaction with social support				**X**	
Parental worries			**X**	**X**	**X**
Serious life events	**X**		**X**	**X**	**X**
Fuzzy-difficult temperament			**X**		
Reported by children					
Self-esteem					**X**
Body dissatisfaction					o
Children's					
Weight			o	o	o
Height			o	o	o
BMI			o	o	o
Waist circumference					o
Saliva cortisol					o

Summary results Paper I

Paper I examined the relation between parents reported psychological measurements, with a focus on parenting stress, and children's self-esteem. Cross-sectionally higher parenting stress at age 8 was related to lower self-esteem in each of the domains assessed, physical

characteristics: odds ratio = 1.43, $p < .001$, skills and talents: odds ratio = 1.13, $p < .001$, mental well-being: odds ratio = 1.76, $p < .001$, relationship to family: odds ratio = 1.74, $p < .001$, relationships to others: odds ratio = 1.56, $p < .001$, as well as to self-esteem summarized for all domains: odds ratio = 1.57, $p < .001$. Furthermore, the relation between parenting stress and self-esteem was significant over time (for details: Table 3 in Paper I). The psychological measurements reported by the parents, namely dissatisfaction of social support, parental worries, and serious life events were also related to lower self-esteem for children but parenting stress was the strongest predictor (for details: Table 3 and 4 in Paper I). Adjusting for demographic factors, fuzzy-difficult temperament, or other psychological stress variables, did not affect the relation between parenting stress and the child's self-esteem (for details: Table 4 in Paper I).

Paper II

An overview of variables examined in Paper II is shown in Table 8. Saliva samples were collected in a subsample of ABIS and 118 samples collected before and 115 samples collected after a blood sample was drawn yielded samples that could be analyzed for cortisol. First, outliers were identified and removed (values > 3 * mean) data was checked for possible confounders. As reported in Paper II, time of day was related to cortisol sample 1, $\beta = -0.35$, $t = 4.4$, $p < .001$, and after adjusting for time of day, children who had brushed their teeth had higher cortisol levels for

sample 1, $F(1,114) = 6.19$, $p = .01$, whereas no difference was found for having eaten, $F(1,114) = 1.77$, $p = .19$, or having exercised, $F(1,114) = 1.80$, $p = 0.18$. Furthermore, children who did not provide a blood sample had lower cortisol levels, $F(1,114) = 6.74$, $p = 0.01$. Therefore, children who had brushed their teeth, $n = 29$, or who did not provide a blood sample, $n = 8$, were removed from further analysis, leaving for cortisol sample 1 $n = 84$, for cortisol sample 2 $n = 83$, and for paired samples $n = 82$ cases for further statistical analyses. Sample 1 had a mean cortisol level of 3.46 nmol/l ($SD = 2.53$) and sample 2 of 3.43 nmol/l ($SD = 2.97$). Details are shown in Table 1 in Paper II.

Summary results Paper II

Paper II examined the relation between cortisol levels and parenting stress, serious life events, and children's self-esteem as predictors. Repeated measure general linear models indicated a relation between higher parenting stress at age 1 ($p = .03$) and at age 8 ($p < .01$), and elevated cortisol levels (for details: Table 2 in Paper II). No relation was found for serious life events (for details: Table 3 in Paper II). Self-esteem in the domain of mental well-being was related to cortisol levels ($p = .02$), with children who had lower self-esteem had higher cortisol levels (see also Results in Paper II).

Table 8 *Variables examined in Paper II are shown in bold and marked with X. Saliva cortisol was the dependent variable.*

	Follow-up				
	Birth	Age 1	Age 2	Age 5	Age 8
Reported by parents					
Parenting stress		**X**	**X**	**X**	**X**
Quantity of social support				o	
Dissatisfaction with social support				o	
Parental worries			o	o	o
Serious life events	**X**		**X**	**X**	**X**
Fuzzy-difficult temperament			o		
Reported by children					
Self-esteem					**X**
Body dissatisfaction					o
Children's					
Weight			o	o	o
Height			o	o	o
BMI			o	o	o
Waist circumference					o
Saliva cortisol					**X**

Paper III

An overview of variables examined in Paper III is shown in Table 10.

Body conception

At age 8 children answered items regarding their body. 3822 children answered the item assessing perceived body size, with a mean of 4.12 (*SD* = 1.00, range: 1 – 9). 3804 children answered the item assessing ideal

body size, with a mean of 4.01 (*SD* = 1.01, range: 1 – 9). 3796 children answered both items and body dissatisfaction was calculated. The mean was - .11 (*SD* = 0.85, range: -8 – +5). Table 2 in Paper III presents details for boys and girls and different age groups, separately. As reported in Paper III, girls perceived their body as bigger and were less satisfied with their body than boys. No differences were found between 7.5, 8, and 8.5 year old children.

BMI, overweight and obesity

Data in the current thesis for weight and height was reported by parents for themselves and their children. A validation of the self-reported data was undertaken by comparing weight and height data reported in ABIS questionnaires and recorded in the health journals at the well child clinics at age 1 and age 5. Correlations were for weight r > .95, and height r > .85, all p < .001 (Karina Huus, personal communication, January 2009). Furthermore, at age 8 weight and height of a convenience subsample of 126 children was also measured by a research staff as reported in Paper II. Data reported in ABIS questionnaires and measured by research staff showed for weight, $r = .96$, $n = 111$, $p < .001$, height, $r = .93$, $n = 110$, $p < .001$, and BMI, $r = .92$, $n = 108$, $p < .001$, high Pearson correlations.

Prevalence of overweight and obesity is shown in Table 9. A comparison between boys and girls, showed a higher prevalence of overweight and obesity for girls at age 2, $\chi^2(2, N = 8038) = 14.38$, $p < .001$,

and age 5, $\chi^2(2, N = 6748) = 22.50$, $p < .001$, but not at age 8, $\chi^2(2, N = 2995) = 3.50$, $p = .17$. Details for weight, height, BMI, and waist circumference at age 8 were reported in Table 1 in Paper III.

Table 9 *Prevalence of overweight and obesity for boys and girls from age 2 through to age 8.*

	Follow-up					
	Age 2		Age 5		Age 8	
	N	%	N	%	N	%
Boys						
Normal weight*	3572	86.0	3015	85.0	1360	86.7
Overweight	506	12.2	404	11.4	178	11.3
Obese	77	1.9	128	3.6	31	2.0
Girls						
Normal weight*	3238	83.4	2582	80.7	1203	84.4
Overweight	533	13.7	465	14.5	186	13.0
Obese	112	2.9	154	4.8	37	2.6

* including underweight.

Summary results Paper III

Paper III examine the relation between body measurements (weight, height, BMI, and waist circumference) and body conception (perceived and ideal body size and body dissatisfaction). Weight correlated with perceived body size, all r > .42. Correlations between height and perceived body size were explained by the correlation between weight and height. Correlations between height and perceived body size, when controlled for weight, were $r = -.19$ for boys and $r = -.18$ for girls, both

$p < .001$. Correlations between weight and perceived body size, controlled for height, was for boys: $r = .42$, $p < .001$, and girls: $r = .45$, $p < .001$ (adjusted correlations not reported in Paper III). Details for correlations between body conception variables and body measurement variables are shown in Table 3 in Paper III.

Self-esteem was not related to BMI values (data not shown). However, when comparing self-esteem between weight groups girls with obesity, compared to girls with normal weight, had lower self-esteem in the domains physical characteristics: odds ratio = 2.50, $p < .001$, skills and talents: odds ratio = 1.68, $p = .04$, mental well-being: odds ratio = 2.51, $p < .001$, relationships to others: odds ratio = 2.09, $p < .01$, and self-esteem summarized for all domains: odds ratio = 2.02, $p < .001$, but not for relationship to family: odds ratio = 1.72, $p = .67$. Girls with underweight had lower self-esteem for physical characteristics: odds ratio = 1.54, $p = .01$ compared to girls with normal weight (details are shown in Table 5 in Paper III). Self-esteem did not differ between boys with underweight, normal weight, overweight or obesity.

Body dissatisfaction, was related to self-esteem for boys and girls. The more dissatisfied children were, regardless of whether they wanted to be thinner or bigger, the lower was their self-esteem. Only the domain skills and talents was not related to body dissatisfaction (details are shown in Table 6 in Paper III).

Table 10 *Variables examined in Paper III are shown in bold and marked with X. Body dissatisfaction was the focus of Paper III.*

		Follow-up			
	Birth	Age 1	Age 2	Age 5	Age 8
Reported by parents					
Parenting stress		o	o	o	o
Quantity of social support				o	
Dissatisfaction with social support				o	
Parental worries			o	o	o
Serious life events	o		o	o	o
Fuzzy-difficult temperament			o		
Reported by children					
Self-esteem					**X**
Body dissatisfaction					**X**
Children's					
Weight			o	o	**X**
Height			o	o	**X**
BMI			o	o	**X**
Waist circumference					**X**
Saliva cortisol					o

Paper IV

An overview of variables examined in Paper IV is shown in Table 11. Results reported in Paper IV showed a relation between serious life events (only in a model adjusted for demographic variables) and obesity at age 5 (adjusted odds ratio = 1.42, $p = .03$) and between parental worries and obesity at age 5 (crude odds ratio = 1.69, $p = .02$, adjusted odds ratio = 2.06, $p < .01$). Parenting stress and dissatisfaction with social support were not found to be related to obesity. The composite measure, summarizing parenting stress, dissatisfaction with social support, parental worries and serious life events, showed a relation to obesity. Children living with high stress in the family had cross-sectionally (crude odds ratio = 1.78, $p < .01$, adjusted odds ratio = 2.12, $p < .01$) and longitudinally (crude odds ratio = 2.55, $p < .01$, adjusted odds ratio = 2.63, $p < .01$) a higher risk for obesity than children without stress in the family. Further details are shown in Table 2 in Paper IV. Stratification of the data according to mothers' BMI one year after the children's birth showed that odds rations for obesity were even higher for children whose mother had a BMI < 25 and experienced high stress in the family cross-sectionally (crude odds ratio = 2.86, $p < .01$, adjusted odds ratio = 2.71, $p = .01$) and longitudinally (crude odds ratio = 4.05, $p < .01$, adjusted odds ratio = 4.52, $p < .01$). Further details are shown in Table 3 of Paper IV.

Table 11 *Variables examined in Paper IV are shown in bold and marked with X. Children's weight group classification (age and gender adjusted BMI < 30 vs. BMI ≥ 30) was the dependent variable.*

	Follow-up				
	Birth	Age 1	Age 2	Age 5	Age 8
Reported by parents					
Parenting stress*		o	**X**	**X**	o
Quantity of social support				o	
Dissatisfaction with social support*				**X**	
Parental worries*			**X**	**X**	o
Serious life events*	o		**X**	**X**	o
Fuzzy-difficult temperament			o		
Reported by children					
Self-esteem					o
Body dissatisfaction					o
Children's					
Weight			o	**X**	o
Height			o	**X**	o
BMI			o	**X**	o
Waist circumference					o
Saliva cortisol					o

* These variables were used for the composite measure of psychological stress in the family.

Additional analyses age 8

In none of the papers the relation between composite measures and children's weight group classification at age 8 was presented. Table 12 shows the relations between composite measure at age 2, at age 5, and

cross-sectionally at age 8 and weight group classification (age and gender adjusted BMI < 30 vs. BMI ≥ 30) at age 8. Odds ratios for obesity at age 8 were higher for high stress in the family at age 2 and age 8.

Table 12 *Crude Odds Ratios (OR) estimating the relations between composite measures of stress and obesity (age and gender adjusted BMI ≥ 30) at age 8.*

	Crude Odds Ratios for obesity at age 8			
	N	OR	95%CI	*p*
Composite measure at age 2				*<.01*
Not exposed	1654	reference		
Exposed in one domain	568	2.48	1.36 - 4.52	*<.01*
High stress in the family	70	4.12	1.39 - 12.20	*0.01*
Composite measure at age 5				*0.32*
Not exposed	1256	reference		
Exposed in one domain	722	1.60	0.87 - 2.95	*0.13*
High stress in the family	136	1.27	0.37 - 4.28	*0.71*
Composite measure at age 8				*<.01*
Not exposed	1773	reference		
Exposed in one domain	893	1.29	0.75 - 2.22	*0.35*
High stress in the family	117	3.75	1.70 - 8.31	*<.01*

Attrition analyses

Figure 3, 4 and 5 show results of attrition analyses for psychological variables. At age 5 the participation rate was 46.3 % out of 16070 participants at birth. Figure 3 visualizes means for psychological

variables measured before age 5 according to participation or non-participation at age 5. No significant difference was observed. 24.6 % of parents participated at age 8 and Figure 4 visualizes means according to participation or non-participation at age 8. Significant differences were observed only for Parental worries at age 2, mean difference = .10, $t(6549, \textit{equal variance not assumed}) = 2.98$, $p < .001$, Fuzzy-difficult temperament at age 2, mean difference = .06, $t(8658) = 2.98$, $p < .01$, and dissatisfaction with social support at age 5, mean difference = .04, $t(6993) = 2.54$, $p = .01$. Figure 5 shows the prevalence of serious life events according to participation and non-participation at the next follow-up. No significant differences were observed.

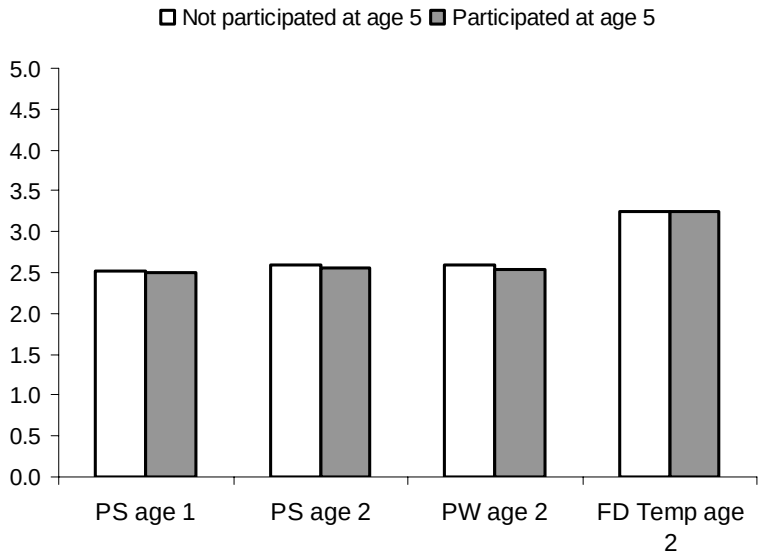

Figure 3 Comparison of mean values for psychological variables assessed before age 5 between participation and non-participation at age 5. PS: Parenting stress, PW: Parental Worries, FD Temp: Fuzzy-difficult Temperament, for all independent *t* test comparison: $p > .05$.

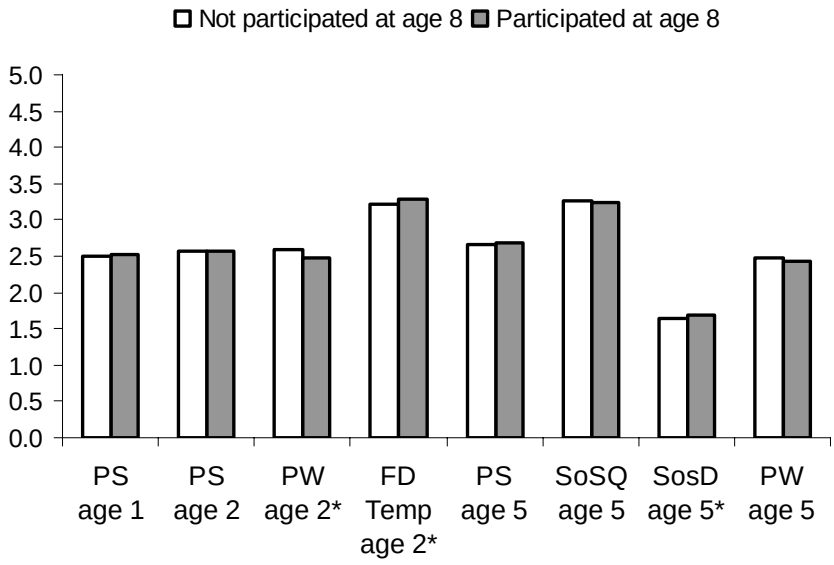

Figure 4 Comparison of mean values for psychological variables assessed before age 8 between participation and non-participation at age 8. PS: Parenting stress, PW: Parental Worries, FD Temp: Fuzzy-difficult Temperament, SoSQ: Quantity of Social Support, SoSD: Dissatisfaction with Social Support. * Independent *t* test comparison: $p < .01$, for all other comparisons $p > .05$.

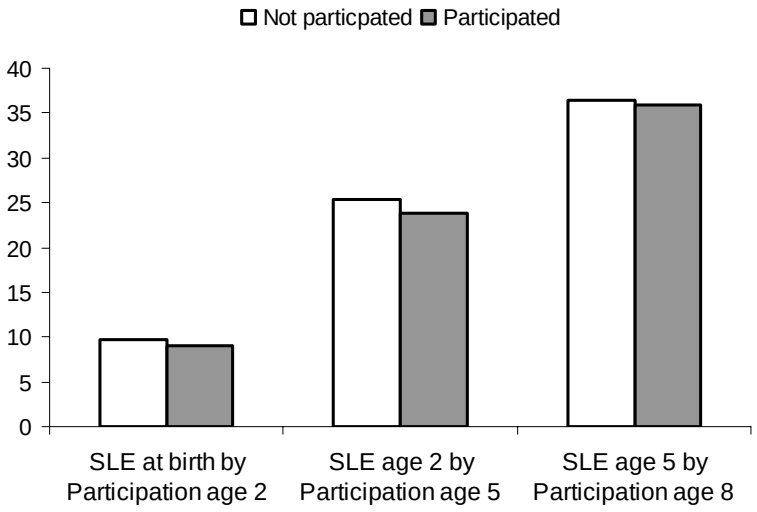

Figure 5 Comparison of prevalence for experience of serious life events (SLE) between participation and non-participation at the next follow-up. For all χ^2 test comparisons, $p > .05$.

Discussion

Results presented in the current thesis and Paper I to Paper IV can be summarized as follows. Internal consistencies of psychological measurements used to assess parents' psychological stress in ABIS were good. Parenting stress and parental worries could be tested for stability and were found to be good. Internal consistency of children's self-esteem was lower, in particular in each domain of self-esteem. Paper I indicated a relation between parents' psychological stress and children's self-esteem. Paper II indicated a relation between parenting stress and cortisol levels, even in longitudinal analyses. Paper III indicated a relation between children's body dissatisfaction and self-esteem, and between body dissatisfaction and weight, BMI, and waist circumference but not height. Paper IV indicated a relation between parents' psychological stress and odds ratios for childhood obesity. Taken together these results indicate a relation between psychological stress and childhood obesity and suggest that psychological stress may be a contributing factor in the development of childhood obesity. That psychological stress is a contributing factor was not tested directly, but longitudinal analyses and theory support the possibility that psychological stress contributes to childhood obesity.

Methodological issues

Several methodological issues need to be discussed in order to clarify what the results mean. The main points discussed are construct validity, attrition and statistical issues. Construct validity is important because it needs to be clear what has been measured. Attrition can influence the result due to an unintended selection of the participants. Statistical issues that need to be clarified for the current data were the sample size and the relevance of the relations found.

Construct validity

The psychological measurements parenting stress, social support and fuzzy-difficult temperament were widely used and tested. Internal consistency of these instruments was high in the current data, too, supporting good construct validity for these measurements.

The social support instrument has been used before but not by solely using the qualitative part, that is dissatisfaction with social support (in Paper IV: lack of social support). It correlated well with the quantity of social support, but factor analyses could show if these were actually two different dimension of the same construct or if they were better summarized as one score. These analyses were outside of the scope of the current thesis. It was assumed that the qualitative part better represented an individual perspective as the personal appraisal of social support was measured. Hence, a high score on dissatisfaction with social

support better represented stressful experiences with social support, than a low score in the quantity of social support part.

Parental worries has not been used in other studies. As pointed out in the introduction worries were related to anxiety and were found to be able to differentiate between depression and anxiety. The aim of the instrument was not to identify or diagnose clinical anxiety but to assess less extreme affects of parenthood. Two terms, "calm" and "worried", were used to define the opposing ends of the scale, but these terms did not necessarily define one dimension. High Cronbach's alpha suggested that this instrument assessed a comprehensive dimension, because variation was not due to confusion or misunderstanding by participants, rather differences in answers corresponded to differences in attitudes in one domain. The correlations over time ($r > .55$) suggested some stability for this domain of parenthood. Parents who worried a lot about their child may have been overinvolved / overprotective and hindered the children in their development. As Bayer et al (2006) suggested overinvolved / overprotective parenting related to children's internalizing problems. Further studies could show how parental worries relate to parenting styles and how it impacts parent-child interactions and relations. In the current thesis, parental worries are interpreted as measuring a relevant domain of parenting, with high parental worries as a burden and a stress factor for parents. Parental worries were related to parenting stress, but described a different aspect of parenthood.

Serious life events were assessed with one yes / no-item. Following Holmes and Rahe (1967) and Coddington (1972a, 1972b), researchers interested in serious life events have used checklists that presented various events and participants answered if any of those occurred in their life. One problem with this approach was that each person could interpret and be affected by an event differently. Researchers have tried to estimate the magnitude of impact on peoples lives for each event (e.g., Dohrenwend, Krasnoff, Askenasy, & Dohrenwend, 1978) but again this failed to take an individual appraisal into account. The item used in the current thesis had a subjective part by stating that the parent experienced an event that he/she "perceived as a serious life event". The intention was to measure some general life stress with this item. Examples were given for what may be seen as a serious life event but parents could also think of a different event, which they perceived as difficult and answered with "yes". In their eyes the event they experienced may be comparable to a divorce or a death of a relative. Therefore, this item allowed for a subjective interpretation of serious life events or an impact on one's life, which is not part of checklists. ABIS questionnaires at age 2 to age 8 asked for specific events, as well, but the specific events have not been studied in the current thesis and an individual appraisal would have to be taken into account for each specific event.

Children's self-esteem was measured with an instrument that was developed and validated in Sweden. Domains of self-esteem showed low internal consistencies in the current data, as Cronbach's alpha was low

for all domains, $\alpha < .50$, except for mental well-being, $\alpha = .55$. Cronbach's alpha is based on the number of items in the questionnaire and a ratio of the average inter-item covariance and average item variance. A high alpha, arguably > .70, indicated differences in answers were due to different opinions, attitudes, or in this case, self-esteem and not because the questionnaire was confusing (Nunnally & Bernstein, 2000). That the items were dichotomous was not a problem, rather difficulties in interpreting items and differences in distributions could be problematic (Nunnally & Bernstein, 2000). As these domains have been validated before they should be meaningful and representing constructs that were important for children's self-esteem and behavior. Harter (1999) questioned the idea of a sumscore over several domains for self-esteem, as discussed in Paper I. Recently, a Swedish instrument to assess stress in children has been developed and validated (Osika, Friberg, & Wahrborg, 2007). Several of the items used are similar to items used in the *I think I am* instrument. Factor analyses and cluster analyses could be used in future studies to examine other possibilities of summarizing items used in the *I think I am* instrument in order to study stress. Underlying constructs of the self-esteem instruments may be helpful to directly assess stress in children but this approach needs further research.

Two studies using the *I think I am* instrument (Henricsson & Rydell, 2004; Jutengren & Palmèrus, 2007) referred to the instrument as a measure of self-perception, rather than self-esteem as used in the current thesis and other studies (Renman, Engström, Silfverdal, & Åman, 1999; Räty, Larsson, Söderfeldt, & Wilde Larsson, 2005). Other terms used for

this instrument were self-image and self-concept. Harter (1999) argued that statements about the self, such as "I have a nice face." or "I am good at drawing.", also include a judgmental and affective part, in particular in the age group examined in the current thesis. It is therefore difficult to differentiate between self-perception, self-concept, self-image, and self-esteem and the *I think I am* instrument is referred to as a measure of self-esteem in the current study.

There is a debate in the literature regarding whether the figure preference task is a valid instrument to measure body dissatisfaction for children 8 years old or younger. Paper III focused on this issue and it was suggested that children as young as 7.5 years can choose an appropriate silhouette on the scales from "very thin" to "very obese" in relation to their own weight, BMI, and waist circumference. Furthermore, a relation between increased body dissatisfaction and lower self-esteem was found, suggesting that body dissatisfaction measured a psychological relevant construct. It was also argued in Paper III that the measured psychological construct could be related to experience of stress in children.

Attrition analyses

Attrition analyses presented in Paper I, Paper IV, and the current thesis indicated no differences for parenting stress and serious life events between participants and non-participants at follow-ups. Due to the large sample size, even small differences between participants and non-

participants would have been significant. Parental worries was slightly but significantly lower in the participants group. Interestingly, fuzzy-difficult temperament and dissatisfaction with social support was slightly, but significantly higher in the participant group. Therefore, it was concluded that there was no systematic attrition due to stress as measured with the psychological variables in ABIS. However, as attrition analyses in Paper I and IV suggested attrition in ABIS was related to parents' origin, education, and marital status, which means that attrition at follow-ups was related to a more socioeconomic exposed situation. A more socioeconomic exposed situation can be related to psychological stress and to obesity and therefore confound some relations examined in the current thesis. As the main statistical analyses were controlled for variables related to socioeconomic situations, relations reported cannot be explained by socioeconomic situations. Also, the confounding attrition would lead to a lower chance of finding or an underestimation of the relation between psychological stress and obesity, as presented in Paper IV.

Attrition analyses in the current thesis were helpful to identify systematic drop out from ABIS. However, a conceptual problem with these analyses was that participants and non-participants were compared on historical not current data, for example attrition analyses at age 8 compared data collected at previous follow-ups. Parents who decided not to participate at age 8 could have scored higher on parenting stress but in the past did not have higher stress scores. Therefore, it was

possible that non-participants were more stressed at follow-up but the stability of stress instruments suggested that this was unlikely.

Sample size and small differences

One strength of ABIS was the sample size because even small differences between groups would be found. The main question was then if the small differences were relevant. Some attrition analyses showed small but significant differences. It was concluded that these differences were not relevant for explaining the main findings.

One of the main findings was a relation between parenting stress and self-esteem. Mean for lack of self-esteem, for example in the relationship to family domain, was about .3 for low parenting stress and about 1.8 for high parenting stress (cf. Figure 1 in Paper I). The maximum score was 6 for lack of self-esteem in the relationship to family domain. Compared to the maximum score differences in self-esteem were not big but compared to the high proportion of children with very good self-esteem it was interesting to find this relation.

Another example is the difference found in odds ratios for childhood obesity in age 5 (cf. in Paper IV) between high stress in the family and no stress in the family. The prevalence increased from about 4 % in the reference group to about 8 % in the high stress in the family group. The difference may be seen as small but for the relative few children who live in families with high stress it is a substantial increase in risk for obesity. The current sample size allowed for stratification of the data and

analyses of subgroups confirmed a relation between high stress in the family and childhood obesity in children to mothers with normal weight. Examining interactions of psychological stress with other factors, such as expressions of genes, socioeconomic status, physical activity, and dieting habits, is going to lead to a better understanding of the relation between psychological stress and obesity. To take psychological stress into account when examining childhood obesity gives a good opportunity to better understand the current epidemic of childhood obesity.

Parents' and children's stress

It has been emphasized that psychological stress depends on environmental factors, responses, interactions between these as well as the meaning constructed, that is appraisal, by each person. Therefore, psychological stress instruments focused on the subjective assessment by parents. The discussion of methodological issues showed the construct validity of measurements used in the current thesis. Hence, various aspects of psychological stress that tap into the interaction of environmental factors, responses and the appraisal of the situation have been assessed.

Data presented in the current thesis was based on an unselected sample (other than selected due to attrition) and psychological measurements of parents indicated little experience of stress overall. Means for parenting stress, dissatisfaction for social support, and parental worries are all below the scale means and even the 95th

percentile at age 5 (see Paper IV) was not close to the upper end of the scale (except may be for parental worries). This can indicate that most children do not live under stressful circumstances as measured with these instruments. Nevertheless, even within this small range of stressful experiences a somewhat higher level of stress, as reported by parents, is related to lower self-esteem (Paper I) and higher levels of cortisol (Paper II) for children. Parenting stress, no or little social support, high parental worries, and experience of serious life events may therefore be used as proxies of children's experience of psychological stress.

These findings support the notion that parents' experience of stress, as measured in ABIS, is related to a less than optimal environment for children to grow up in. Parents' experience of stress could result in a slightly higher vulnerability for children when facing stressors, as for example lower self-esteem can be a risk factor for victimization (Salmivalli, Kaukiainen, Kaistaniemi, & Lagerspetz, 1999). Constant elevated levels of cortisol can compromise the elasticity of the HPA axis, which means that the HPA axis cannot respond appropriately in relation to stress (Gunnar & Quevedo, 2007). It has to be noted that levels of cortisol were low in the studied sample (see Paper II) and were not likely to entail a compromised elasticity of the HPA axis. Nevertheless, it is interesting that a relation between parenting stress and children' s cortisol levels can be observed in a sample with rather low parenting stress. Psychological stress then accumulates by adding to the allostatic load, in particular if stress is experienced in several domains. The composite measure of stress summarizes psychological stress over

several domains and is a better estimate of the allostatic load than psychological stress measured separately in each psychological domain.

Children's body dissatisfaction, as argued in Paper III, is not a direct measure of children's psychological stress but is probably related to the psychological stress experienced in childhood. It would indicate at least a higher psychological vulnerability. The decrease of self-esteem in relation to an increase in body dissatisfaction for both boys and girls supports this notion. Preliminary analyses for the relation between parents' psychological stress and children's body dissatisfaction did not indicate a significant relation (data not shown). Other factors, including parents' attitudes or parenting style (Dohnt & Tiggemann, 2005; Phares, Steinberg, & Thompson, 2004), but not parents' psychological stress, may be related to body dissatisfaction.

Stress and obesity

Several different mechanisms might explain the relation found between parents' psychological stress and childhood obesity. Psychological and physiological stress may lead to changes in behavior, for example a more sedative life-style with less exercise and more television, and changes in dieting habits, for example what people eat and how much. Furthermore, physiological stress can interrupt hormonal feedback, changing food demands (Mietus-Snyder & Lustig, 2008) or fat storage (Björntorp, 2001). Probably, these mechanisms act simultaneously and in the current thesis none of these have been studied directly. Other studies

indicated a tendency to increase snacking and to choose snack-type food over other food during stressful periods has been observed in all ages (Cartwright et al., 2003; Oliver & Wardle, 1999; Roemmich, Wright, & Epstein, 2002). Recent findings concerning emotional eating in relation to stress are not clear, as one epidemiological study found a relation (Nguyen-Rodriguez, Chou, Unger, & Spruijt-Metz, 2008) but another did not (Snoek, Van Strien, Janssens, & Engels, 2007).

In the current thesis, parents' psychological stress has been related to childhood obesity. On one hand parents' psychological stress is related to children's psychological stress (as Paper I and II suggest) and therefore children's psychological stress may influence their own behavior and dieting habits, increasing their risk to become obese. On the other hand, parents have a tremendous influence on shaping the environment children live in. Therefore, parents' psychological stress may change their own behaviors and dieting habits, as well as what kind of food and eating culture they provide for their children.

Parents' own weight is a very good predictor for their children's weight but heredity is not the only explanation and other factors need to be considered (e.g., Eisenmann, 2006). Controlling for or stratifying data according to parents' weight are some options to study effects beyond heredity. High stress in the family when parents were normal weight increased the odds ratios for childhood obesity, in particular longitudinally. This further indicates that psychological stress is a factor that needs to be considered. It is likely that psychological stress interacts with several other factors when it contributes to childhood obesity and

for each individual how much each factor contributes may vary. In Paper IV children with obesity have been treated as a group and odds ratios have been calculated on the assumption that this group is homogeneous. The higher odds ratios for stress after stratification indicate that this may not be so. For some groups there may be a higher risk to become obese due to stress than others.

In order to better understand childhood obesity various factors should be taken into account and allow for the possibility that factors vary in how important they are for childhood obesity and for how they interact with other factors. Due to genetics and early adjustments of the stress responses psychological stress may vary in how much influences it has on development of obesity. It follows from this discussion that psychological stress cannot be seen as a single cause for childhood obesity but rather a contributing factor. Stress is not likely to cause obesity for all children but together with other factors may increase the risk, at least for some children, to develop childhood obesity.

Summary

ABIS is a unique project due to the high number of participants and richness of the longitudinal data. Psychological stress is an important factor to study in childhood because it may be involved in the development of mental and physical diseases in childhood and later in life. The current thesis showed that psychological variables measured in ABIS, that is parenting stress, dissatisfaction with social support, parental worries, and serious life events, measured aspects of psychological stress that could be used as proxies for stress experienced in childhood. Higher stress according to these variables was related to lower self-esteem for children. Body dissatisfaction was a better predictor of lower self-esteem than children's weight status. Parenting stress was the strongest predictor for self-esteem and related also to children's cortisol levels.

Conclusions

Psychological variables reported by parents can be used as proxies for children's experiences of stress in epidemiological studies such as ABIS.

Furthermore, body dissatisfaction can be measured with the figure preference task in children at least as young as 7.5 years. This measure might be related to children's experience of stress.

Finally, psychological stress seems to be a contributing factor for childhood obesity. This relation needs to be studied further in order to better understand and intervene in the current epidemic of childhood obesity.

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