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Fat and lean tissue accretion in relation to reward motivation in children

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ABSTRACT

'Reward sensitivity' explains inter-individual differences in the motivation to obtain rewards when reward cues are perceived. This psychobiological trait has been linked to higher consumption of palatable food when exposed to palatable food cues. The current study aims to examine if reward sensitivity explains differences in patterns of fat and lean tissue accretion over time in children. A longitudinal observational study with measurement waves in 2011 (baseline), 2012, 2013, and 2015 was conducted. The sample was a population-based Flemish cohort of children (n = 446, 50% boys and 5.5–12 years at baseline; 38.8% of the baseline sample also participated in 2015). Baseline reward sensitivity of the children was assessed by parent ratings on the Drive subscale of the Behavioral Inhibition System/Behavioral Approach System scales. Age- and sex-independent Fat and Lean Mass Index z-scores (zFMI and zLMI respectively) were computed for each study wave based on air-displacement plethysmography. In girls, but not boys, reward sensitivity was positively associated with the baseline zFMI and zLMI (95% confidence intervals of unstandardized estimates: 0.01 to 0.11 and 0.01 to 0.10 respectively, *P* values 0.01 and 0.02 respectively). Further, reward sensitivity explained 14.8% and 11.6% of the change in girls' zFMI and zLMI respectively over four years: the zFMI and zLMI increased and decreased respectively in high reward sensitive girls (95% confidence intervals of unstandardized estimates: 0.01 to 0.11 and −0.12 to −0.01 respectively, *P* values 0.01 and 0.02 respectively). Hence, girls high in reward sensitivity had significantly higher adiposity gain over four years parallel with lower increase in lean mass than was expected on the basis of their age and height. These results may help to identify appropriate targets for interventions for obesity prevention.

1. Introduction[1]

The psychobiological trait 'Reward sensitivity' (RS) explains inter-individual differences in motivation to approach rewards in response to reward-predicting-cues (Carver & White, 1994). Rewards can be presents, money, social factors (e.g. appraisal), palatable foods (such as sweet and fat rich foods) etc. Individuals learn that the possibility to obtain rewards is associated with certain cues (objects, pictures, smells etc.). These cues can trigger a motivated state in individuals that aims to generate behavior to approach and obtain the associated reward. Applied to palatable food, cues associated with the consumption of palatable food can evoke the tendency to approach and consume these foods, even in the absence of homeostatic hunger (Johnson, 2013). Individuals high in RS have a stronger tendency to approach and obtain rewards when perceiving reward-predicting-cues (Carver & White, 1994). Therefore, it has been proposed that RS contributes to the

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[1] Abbreviations: RS, reward sensitivity; BMI, Body Mass Index; FMI, Fat Mass Index; LMI, Lean Mass Index; zBMI, standard deviation score of BMI based on Flemish reference curves; zFMI, standard deviation score of FMI based on British reference curves; zLMI, standard deviation score of LMI based on British reference curves; BIS/BAS, Behavioral Inhibition System/Behavioral Approach System; AIC, Akiake's Information Criterion.

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variability in adiposity gain in contexts in which food cues are highly present in the daily living environment (e.g. billboards, commercials, vending machines) (Davis, Strachan, & Berkson, 2004).

Considering the current high overweight and obesity prevalence in childhood (Lobstein, Baur, & Uauy, 2004) and its tracking into adulthood (Singh, Mulder, Twisk, van, & Chinapaw, 2008), the development of effective childhood obesity prevention strategies is of great importance. To identify appropriate targets for obesity prevention interventions, confirming and quantifying the association between RS and adiposity gain in children is critical. Different approaches to measure inter-individual differences in cue-triggered reward motivation exist, e.g. neuro-imaging techniques, laboratory-based behavioral tasks, and questionnaires that measure RS to all kinds of reward, i.e. 'general RS', as well as specifically to palatable food reward (Carnell, Benson, Pryor, & Driggin, 2013). To use the information on this association for preventive purposes, the RS measure needs to be easily and practically applicable, and inexpensive; therefore, it is advisable to use questionnaires.

Using a general RS questionnaire, cross-sectional studies have reported higher consumption of palatable food (De Cock et al., 2016; De Decker et al., 2016; Paquet et al., 2010), food cravings (Franken & Muris, 2005), over-eating (Davis et al., 2007), and overweight (Davis & Fox, 2008; De Decker et al., 2016; Dietrich, Federbusch, Grellmann, Villringer, & Horstmann, 2014; Verbeken, Braet, Lammertyn, Goossens, & Moens, 2012) with higher RS. Some of these studies differentiated by sex and reported that this relation was primarily present in females (De Cock et al., 2016; Dietrich et al., 2014). To confirm that higher scores on a general RS questionnaire indeed increase the risk of excess adiposity gain, longitudinal studies are needed but these are as far as we know absent. Therefore, the current study aimed to examine if inter-individual differences in general RS explain differences in fat and lean tissue accretion in children, and if the relation between RS and fat and lean tissue accretion differs in boys versus girls. The consideration of fat and lean tissue accretion instead of weight gain is an important advantage of this study, since lean tissue accretion can importantly contribute to weight gain (Wells, 2000). A positive association between RS and fat as well as between RS and lean tissue accretion over time was hypothesized, and it was hypothesized that this relation was stronger in girls.

2. Methods

2.1. Participants and procedure

Participants were 446 Dutch-speaking Belgian children (50% boys) aged 5.5–12 years at baseline (i.e. 2011). Baseline data on parental reports of children's RS as well as measurements of children's body composition in 2011, 2012, 2013, and 2015 were used (Fig. 1). For all these study waves, children (in most cases accompanied by at least one parent) attended the survey center at a prefixed appointment, on which body composition measurements of the child were conducted and parental questionnaires were filled in. If no parent accompanied the child, one of the parents completed the questionnaires at home.

The children were recruited by random cluster design (all children of twelve primary schools of Aalter were contacted) for the longitudinal "Children's Body Composition and Stress" (ChiBS) study (Michels et al., 2012), with study surveys in 2010, 2011, and 2012. Data from 2010 were not used since RS was assessed for the first time in 2011. All children measured in the ChiBS study were invited via mail, email and, if no response, telephone calls to participate in the follow-up study "Rewarding-FOod ChoicES" (Forces), which is part of the REWARD-project (www.rewardstudy.be), with study surveys in 2013 and 2015. All participants for which baseline RS data were present were included in the current study (i.e. 446 of the 455 children that participated in the ChiBS survey of 2011).

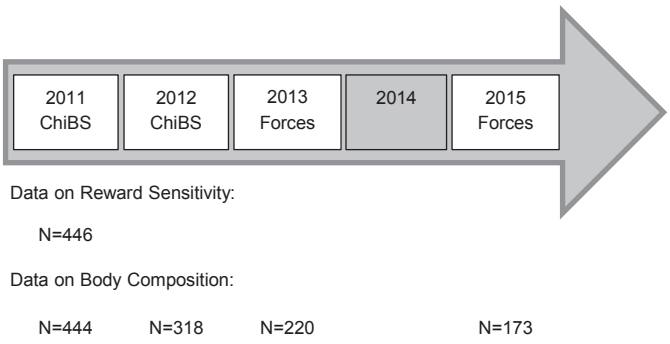

Fig. 1. Number (N) of participants with RS data at baseline and body composition data at baseline and follow-up.

The ChiBS and Forces studies were conducted according to the guidelines laid down in the Declaration of Helsinki and approved by the Ethics Committee of Ghent University Hospital. Written informed consent was obtained from all parents, and all children gave verbal assent.

2.2. Measures

2.2.1. RS

The Behavioral Inhibition System (BIS) and Behavioral Approach System (BAS) scales (Carver & White, 1994) measure a person's behavioral and affective responses to (predicted) punishments and rewards respectively. The BAS scale consists of three subscales, i.e. Fun Seeking (measures the inclination to seek out new rewarding situations), Reward Responsiveness (measures positive affect and excitability when obtaining reward), and Drive (measures the strength of pursuit to obtain reward in response to reward-predicting cues; e.g. our child does everything to get the things that he/she wants). Hence, the Drive subscale is most strongly linked to the RS concept as described in the introduction section. Additionally, of the three BAS subscales, Drive has the highest internal consistency (De Cock et al., 2016; Vervoort et al., 2015) and correlates most strongly with neural responses to food reward cues in multiple loci of the brain reward circuitry (r ~ 0.8) (Beaver et al., 2006). Therefore, the term RS in the text below refers to the sum score of the four items of the Drive subscale, which were scored on a 4-point Likert scale (1 = not true; 2 = somewhat true; 3 = true, 4 = very true; total range on Drive subscale: 4–16). Because the youngest children of the cohort were too young to answer the questionnaire themselves, parents answered a Dutch parent version of the BIS/BAS scale (Vervoort et al., 2015). The Cronbach alpha of RS in the current study (0.85) was comparable with the alpha reported by Vervoort et al. (i.e. 0.85) in children and adolescents aged 2–18 years (Vervoort et al., 2015).

2.2.2. Body composition

At least 2 h before the measurement, children were asked to refrain from physical activity and food. Height was measured to the nearest 0.1 cm. Body weight was measured with the BOD POD® balance, and body volume with the BOD POD® air-displacement plethysmography device (Software version 4.2.4, Life Measurement, Inc., Concord, California, USA), both using standardized procedures (McCrory, Gomez, Bernauer, & Mole, 1995). In accordance to the manufacturer's guidelines, the BOD POD® was