List of studies included in the review – not related to brain physiology

Authors Date Country	Population/ topic	Method	Outcomes/ Variables	Findings
Abraham & O'Dea 2001 Australia	Adol. females 12–14 yrs. To examine pre and post menarcheal female school students in relation to dieting.	Cross-sectional, qualitative study; questionnaires and focus group discussions.	1.weight 2.height 3.BMI 4.dieting: understanding and behaviour 5.menstrual status	51 participants; the concept of dieting that may result in weight loss and the behaviours and feelings associated with dieting did not develop until menarche and is likely to be associated with the rapid increase in height, weight, and body fat during that time.

Andreacci 2004 USA	Pre-pubertal and pubertal adols, 9–14yrs; to determine whether maximal O_2 consumption differed between two groups of black and white children and whether differences existed in hematologic profiles, body composition, and/or physical activity levels.	Cross-sectional study using objective and SR data.	1.x-ray absorptiometry (body composition) 2.computed tomography scan (adipose tissue) 3.PA questionnaire (Modifiable Activity Questionnaire - SR) 4.Tanner stage – prof ax (confirmed by measurements of total testosterone in boys, estradiol in girls) 5.Hb blood levels	87 adols; findings indicate that black pre-pubertal and pubertal children had lower VO2max when compared with their white peers matched for age, pubertal stage, and body mass index; also related to higher physical inactivity levels in the *prepubertal* black children. Difference in VO_2 max between the *pubertal* racial groups was independent of body composition and physical activity level.
Armstrong 2000 UK	Adols 11–13yrs. To examine the influence of gender, growth, and maturation on peak O2 consumption	Longitudal study over 3 years.	1.Peak O2 – annually over 3 yrs 2.Gender 3.Tanner indexes of pubic hair 4.BMI 5.stature 6.skin fold thickness	Gender, age, and maturity differences in the increase in fat-free mass relative to body mass are the predominant influences on the differential growth of boys' and girls' VO2peak in 11–13 yr olds.

Ayele 2013 Ethiopia	Adol. girls 10–19yrs; association between age at menarche and BMI/health related behaviours.	A cross-sectional study design with multistage sampling. Anthropometric measures and questionnaires.	1.Calorie/protein/ coffee intake 2.BMI 3.PA 4.parental education/income 5.sleep hours	Data from 660 Ethiopian girls; Low menarche age independently associated with high calorie intake, high protein diet, greater coffee intake, low physical activity, adequate sleep, and parents' low educational background. Low body mass index, low parents' income, exercise, and Amhara ethnic background were associated with late menarche age.
Baams 2015 Various countries; Dutch study team	Youth 10.5–22.4 yrs Pubertal timing/ Status and sexual behaviour.	SR + MA 1980–2012.	1.Intercourse 2.Combined sexual behaviour 3.Risky sexual behaviour (age, gender and ethnicity also examined)	50 included studies. Early development associated with earlier and more (risky) sexual behaviour, esp in girls.

Baker BL 2007 USA	Adol. girls 11 and 13 yrs. Pubertal timing and PA.	Longitudinal cohort study over 2 years.	1.pubertal stage: blood estradiol levels, Tanner breast staging, and parental report 2.PA (ActiGraph accelerometer 3.BMI/weight status 4.Body fat %	Data from 143 girls; Early-maturing girls had significantly lower self-reported PA and fewer minutes of moderate to vigorous and vigorous physical activity and accelerometer counts per day at age 13 than later maturing girls. These effects were independent of differences in percentage body fat and self-reported physical activity at age 11.

Baker & Davison 2011 USA	Adol girls at 9, 11 and 13yrs; examined predictors of perceived athletic competence and subsequent PA.	Longitudinal study at three time points over puberty.	1. Perceived athletic competence (PAC) using Self-Perception Profile for Adolescents 2. Nonaesthetic versus aesthetic sport participation 3.body fat % 4.breast development (All measured at age 9) 5.Accelerometers were used to measure girls' moderate-to-vigorous physical activity at age 13.	149 adol. girls. More advanced breast development at age 9 was associated with greater relative declines in PAC between ages 11 and 13. Both age 11 PA and the relative change in PA between ages 11 and 13 were significant positive predictors of age 13 moderate to vigorous PA. Girls who participated in non-aesthetic sports at age 9 reported higher PAC at age 11 than those who participated in only aesthetic sports.

Bale 1992 UK	To examine the influence of growth and maturation on functional performance/exercise and metabolic response to exercise from childhood into adolescence/ Adulthood.	Review of evidence relating to growth and maturation on functional performance/exercise and metabolic response to exercise.	1.Forced expiratory volume (FEV) 2.cardiovascular output 3.heart rate	Respiratory factors such as FEV are lower in females after puberty. Cardiac output may also be reduced, with females having faster heart rates and smaller hearts over this developmental period.
Belsky 2011 USA	Adols 11–19 at start of 7 yr study. Genetic plasticity alleles in relation to parenting and self-regulation.	Longitudinal, prospective study; DNA genotyped from buccal samples.	1.Genotyping of alleles. 2.Maternal engagement/ Involvement. 3.Adols and mothers ax of self-regulation, including temper & trustworthiness	1586 adols; males (not females) with more plasticity alleles demonstrated more and less self-regulation with both supportive and unsupportive parenting.

Benefice 2001 Africa	Adol girls, 12–14yrs of the Sereer ethnic group of rural Senegal. To examine energy expenditure and physical activity levels.	Longitudinal study over 2 years of puberty.	1.pubertal status (as assessed by breast development and occurrence of menarche) 2.selected anthropometric dimensions (weight, stature, arm circumference, and six skinfolds) 3.physical activity levels quantitatively assessed using CSA accelerometers 4.food consumption survey using an individual food weighing method.	40 girls; girls in this sample had high levels of energy expenditure. Energy intakes were, on average, sufficient to meet energy and protein requirements, although micronutrient deficiencies were likely to exist. Activity levels declined with age; stature was negatively correlated with both total daily and day-time activity, whereas the body mass index was positively associated with this measure. Pubertal status and subcutaneous fatness were not significant predictors of activity levels.
Biggs & Dolmain 2007 Australia	Adols 9–11yrs 11 months and 13-16yrs. Data from Australian High Schools Health and Fitness Survey.	Retrospective re-analysis of 1985 data to include PA and diet.	1.BMI/girth 2.sleep duration 3.dietary intake: total energy intake, fat intake 4.PA (items 2-4 self-measured)	Short sleep duration predicted overweight/obesity in boys across both age groups, but not in younger group girls. Larger girth was present in younger boys only. Shorter sleep was associated with lower BMI in older girls.

Bitar 1999 France	Adols 10–16yrs; to investigate variations in daily energy expenditure (DEE) and its main components during adolescence and to quantify their significant determinants.	Cross-sectional study.	1.skinfold-thickness 2.bioimpedance analysis 3.Energy expenditure (EE) determined continuously over 24 h by using 2 whole-body calorimeters 4.Tanner stage (prof ax?) 5.BMI	62 adols; the DEE of adolescents measured under standardized conditions varied with sex, body composition, and season, but not with stage of puberty.
Blomeyer 2013 Germany	Adols drinking behaviour at ages 15, 19, 22, and 23. (Cohort data from 3 months of age; children at risk study). Study involving adol. rats also carried out.	Epidemiologic cohort study; interviews and Qs.	Pubertal stage at first drink, plus drinking behaviour at 19, 22, and 23 (drinking days, amount, hazardous drinking).	283 participants; pubertal first drinking predicted elevated adult drinking compared to post-pubertal onset. Corroborated by animal study.

Bordini 2009 USA	Pre-pubescent and pubescent girls, 6–10yrs and 10–13yrs. To determine whether excessive adiposity is associated with alteration of the normal hormonal changes of early pubertal girls.	Cross-sectional comparison of pre and pubescent girls.	1.BMI 2.Overnoght blood samples for lutenising hormone, follicle stimulating hormone and other hormonal assays 3.glucose tolerance test 4.pelvic ultrasound	40 girls (20 per and 20 pubertal girls). Healthy but excess weight girls have significantly blunted sleep-related lutenising hormone production. These data suggest that excess adiposity, in the absence of sex steroid excess, may subtly suppress hypothalamic-pituitary-gonadal function in premenarcheal pubertal girls.

Brandalize 2011 Brazil	Adols 11–14yrs; to assess whether the shift from afternoon to morning classes reduces the duration of sleep and whether this reduction has any relation to body fat.	Follow up (longitudinal) study over two time points, 1yr apart. Adolescents were divided into two groups: an afternoon-morning group (students who shifted from afternoon to morning classes) and an afternoon-afternoon group (students who remained in afternoon classes).	1.Self-reported bedtime, wake-up time, and time-in-bed 2. Adolescent Food Frequency Questionnaire (SR) 3.Body mass index 4.waist circumference 5.body fat percentage (3–5 by direct measures)	379 adols; changing from afternoon to morning, adolescents experienced a significant reduction in hours of sleep on school days. Results found no effect of the school schedule change on weight gain. The time-in-bed reduction in the period analysed cannot be considered to be a mediating factor to modifications in overweight anthropometric indicators.

Buchmann 2009 Germany	Participants drawn from 'Children at Risk' study (birth-adulthood – same overall study as Blomeyer et al, 2013); current data from ages 15 & 19 years.	Prospective, cohort study. Structured interviews with adols and parents.	1.Age at first drink 2.Current drinking behaviour 3.Risk factors, including early adversity/psychopathology, parental consumption 4.genotype	304 participants; Younger age of first drink predicted by 5-HTTLPR genotype, but even controlling for this, early age of drinking onset remained a strong predictor of heavy alcohol use in early adulthood.
Buchanan 1992 USA	To evaluate evidence relating to hormones, mood and behaviour in adols.	Review of evidence. Exact methods not specified.	1.hormone levels 2.affective behaviours 3.delinquent behaviours	Not all adolescents exhibit aggressive or delinquent behaviour, even although all adolescents experience hormonal increases. Socio-cultural aspects and timing of puberty are influencing factors.
Cairney 2014 Canada	Adols 11–14yrs; Effects of biological and chronological age on PA levels.	Prospective longitudinal study of different cohorts.	1.PA – self reported 2.anthropometric measures 3.biological age (peak height) 4.chronological age 4.gender	2100 participants; rate of physical decline in PA was greater in girls. Biological age was a stronger predictor of participation than chronological age.

Calamaro 2010 USA	Data from 'ADD Health' study; youth aged 12–18 years	Longitudinal study from 2 time points, 1–2 years apart. Survey data from students and parents.	1.Obesity (BMI) 2.Sleep duration 3.Nutrition 4.Physical inactivity (recall of TV viewing) 5.Depression Covariates of age/race/gender/ parental income	13,568 participants; Short sleep duration not predictive of later obesity, but depressed adols twice as likely to be obese, and those who watched ≥ 2hrs TV/day were 37% more likely.
Campbell BC 2005 Zimbabwe	Boys living in Zimbabwe, aged 12–18yrs; To explore the relative timing of puberty and the relationship with sexual behaviour.	Cross-sectional study. Anonymous questionnaires and blood specimens collected.	1.spontaneous nocturnal emission (self-report) 2.secondary sexual characteristics 3.salivary testosterone 4.age of first sexual fantasy 5.non-coital sexual behaviour 6.coitus (sex with a girl)	Data from 442 boys living in Zimbabwe; First spontaneous nocturnal emission was a stronger predictor of sexual behaviour than secondary sexual characteristics, and may be used as a marker of pubertal timing. Variation in testosterone is associated with onset of sexual behaviour, beyond its relationship with developmental timing.

Carskadon MA 2014	Adols second decade; sleep regulatory changes, behaviour and caffeine use.	Review article. Methods used in review not specified.	Circadian timing system (incl. melatonin secretion), and sleep homeostatic system (measured by EEG) examined, plus actual sleep hours, and use of caffeine.	Being awake longer is easier during adolescence, but need for sleep is unchanged, producing a ‘social jet lag’ with health and behavioural consequences. Sleep deficits may result in increased caffeine use, to delay sleep at night and increase feelings of being alert during the day. Effectiveness of this questioned.
Carskadon MA 2011 USA	Adols second decade; sleep patterns and regulation.	Review and discussion of sleep hypotheses relating to adolescence and sleep patterns. Review methods not specified.	1.sleep regulation/patterns in adolescents 2.psychosocial factors, such as parental influence, independence, electronic device use, school start times 3.health implications e.g. mood, behaviour	Whilst there is a reduction of sleep amount in adolescence, sleep need does not decline. Several hypotheses discussed: Circadian period (internal day length) may become longer; there may be altered sensitivity to light phases. Bed times and effects of electronic devices further impact on sleep patterns.

Carskadon 1998 USA	Adols 14–16yrs. To examine effects on adolescent sleep patterns, sleepiness, and circadian phase of a school transition requiring an earlier start	Cross-sectional design (some further data was collected, but not reported in paper).	1.Two weeks of actigraphy measurement 2.sleep diaries at home 3.22-hour laboratory evaluation 4.evening saliva samples every 30 minutes in dim light for determination of dim light salivary melatonin onset phase (DLSMO) 5.overnight sleep monitoring 6.multiple sleep latency test (MSLT)	40 adols; early start time was associated with significant sleep deprivation and daytime sleepiness. The occurrence of REM sleep on MSLT indicates that clinicians should exercise caution in interpreting MSLT REM sleep in adolescents studied on their usual schedule when that schedule involves early rising enforced by alarm clocks, parents, or both.

Chen 2012 Taiwan	Normal, overweight and obese adols; to explore the influence of pubertal development on autonomic nervous system function in overweight and obese children and the concurrent effects on their physical activity.	Adols 9–13yrs. Cross-sectional study with experimental (overweight/ obese) and control (normal weight) groups.	1.electrocardiography heart rate variability (as a marker of autonomic function) 2.Pubertal Development Scale (SR) 3.Physical Activity Questionnaire of Children (SR) 4.BMI	171 adols; overweight/obese children had significantly lower heart rate variability, which was positively correlated with their physical activity levels. Overweight/obesity adversely affects the autonomic nervous system function of children especially during their pubertal development.
Clavien 1996 Switzerland	Adols 9–19. To investigate if modifications in food habits are associated with pubertal maturation, particularly in affluent societies.	Cross-sectional survey was performed in the context of a prospective study of bone mass acquisition during adolescence.	1.5-day dietary diary 2.weighing of food intake (by participants) 3.BMI 4.Tanner stage (prof ax) 5.macronutrient ax (from dietary intake)	193 adols; study indicates that the type of diet which has been linked with several chronic diseases in adults living in developed countries already prevails before pubertal maturation. This dietary pattern changes marginally during pubertal development.

Coldwell 2009 USA	Adols 11–15yrs; to assess perceptual, physiological and eating habit differences between children preferring solutions high in sugar and children preferring solutions low in sugar.	Cross-sectional study using objective measures and SR questionnaires.	1.concentration of oestrogen and progesterone (females), and testosterone (males) 2.biomarker of bone-growth (urine) 3.body fat % 4.puberty stage (Tanner stage, and Pubertal Development Scale – both SR) 5.dietary habits (Dutch Eating Behaviors Questionnaire) 6.Taste using Green's Labeled Magnitude Scale (LMS) 7.sreum leptin levels 8.Plasma insulin levels	143 participants; bone growth and plasma leptin adjusted for body weight were significantly lower in the low preference group. Children with high and low preference patterns did not differ in sensory aspects of sucrose perception, nor did they differ in age, body mass index percentile, or dietary restraint. The change in sugar preference from high to low during adolescence appears to be associated with the cessation of growth.

Costello 2007 USA	Adols 9–13 (at start) from Great Smoky Mountains Study. Puberty and alcohol use.	Longitudinal study; annual interviews until 16yrs with adols and parents.	1.alcohol and drug use 2.psychiatric disorders 3.life events 4.blood assays of pubertal hormones 5.Tanner staging (self ax)	1420 participants; Controlling for age, Tanner stage predicted alcohol use (including problem drinking) in both genders, with more marked effects in those who matured early, esp those with deviant behaviour peers. Lax supervision in girls, and family problems/poverty in boys were further predictive.
Cumming SP 2014 UK	Adols at 11 and 13yrs from the Avon Longitudinal Study of Parents and Children; to measure the associations between maturation, body composition and PA.	Longitudinal study from birth. Data from age 11 and age 13yrs in this study.	1.biological maturation (% of predicted mature height) 2.BMI 3.body composition (DXA scan) 4.PA/sedentary time	1351 adols; maturation was associated with less PA and more sedentary time in boys, but not girls; Maturity at 11 did not predict PA or sedentary behaviour at 13 in either gender.

Cumming SP 2012 UK	Adolescents, 12–18 years. Maturity and physical activity	Review; methods not specified in detail.	1.Maturation 2.Physical activity 3.Direct effects 4.Mediating effects 5.Moderating effects	A biocultural model is presented. Differences in maturation have direct effects on physical activity, although other associated effects may be both direct and indirect.
Cumming SP 2011 UK	Adolescents, 11–15 yrs mean age 13.2yrs. physical self-concept, biological maturity status, and PA.	Cross-sectional study	1.Estimated maturity: % of predicted adult height 2.Physical Activity Questionnaire for Adolescents 3.Children and Youth's Physical Self-Perceptions Scale 4.BMI	407 female adols. Advanced maturation is associated with less involvement in PA, and perceptions of being less attractive. Perceptions of attractiveness and sport competence predicted more positive self-worth, which predicted greater involvement in PA.
Cumming SP 2009 UK	Adols 13–15yrs; to examine relations btwn biological maturity, body size and exercise behaviour.	Pilot study; longitudinal study; two time points, 1 yr apart.	1.Leisure-Time Exercise Questionnaire 2.Estimated maturity: % of predicted adult height 3.BMI	185 adols. Maturity status was positively, but weakly, associated with exercise in males, and negatively associated with strenuous exercise in females. Early maturation was associated with greater overweight and obesity.

Cumming SP 2008 UK	Adols, mean age 14.04yrs; to examine gender and biological age in relation to exercise behaviour.	Cross-sectional study. Questionnaires.	1.Leisure-Time Exercise Questionnaire 2.Estimated maturity: % of predicted adult height	186 adolescents; when examined in a same chronological age cohort, boys reported significantly greater exercise behaviour than boys. When biological age was controlled for, gender differences were no longer apparent.

Cuypers 2012 Norway	Adols 13–19 years old from the HUNT study; to investigate whether obesity-susceptible genetic loci in adults influence adiposity traits in adolescence and influence BMI/ waist circumference (WC) from adolescence into young adulthood. Also examined whether PA modifies the effects of these genetic loci on adiposity-related traits.	Cross-sectional and longitudinal approaches.	1.Genetic predisposition score 2.BMI 3.Waist circumference 4.Pubertal Development Scale (SR)	1643 adols; results suggest that obesity-susceptibility genetic loci established in adults affect BMI and WC already in adolescence. However, an association with change in adiposity-related traits from adolescence to adulthood could not be verified for these loci. Neither could an attenuating effect of physical activity on the association between the obesity-susceptibility genes and body fat estimates be reveal.

Dahl & Lewin 2002 USA	Adols; sleep regulation, biological and psychosocial domains.	Discussion and review.	1.Biological changes in sleep regulation during pubertal development 2.Circadian changes/regulation (biological clock) 3.Emotional domains	There appears to be a biological basis for the change from lark to owl type sleeping patterns in adolescence. Depth of sleep decreases during adolescence. Insufficient sleep can adversely affect mood and concentration ability.
Davison 2007 USA	Adol girls 11–13yrs. Study examines girls' response to puberty and enjoyment of PA.	Longitudinal cohort study of 2 timepoints:11 and 13yrs.	1.Tanner breast stage 2.Estradiol levels 3. Pubertal stage on Pubertal Development Scale (ax by mothers) 4.psychological well-being 5. Physical Activity Enjoyment Scale 6.Daily minutes of moderate-to-vigorous PA	178 girls; more advanced pubertal development at age 11 associated with lower psychological well-being at 13yrs. Subsequent lower enjoyment of PA, and lower moderate-to-vigorous PA levels.

Devlin 2010 USA	Female adols 11–13yrs at start of study, from Young Women's Health Study; to assess femoral neck strength index at age 17 in young women with varying PA levels and oestrogen levels in 3 years after menarche.	Longitudinal study over 10yrs; biannual data collection for the first 4 years (ages 12–16) and annual thereafter (ages 17–22), for a total of 15 study visits from ages 12 to 22.	1.DXA bone densitometer readings 2.Hip Structure Analysis 3.Age at menarche (SR) 4.estradiol levels (urine) 5.calcium levels (urine) 6.vitamin D intake (SR) 7.integrated physical activity score (SR + objective measures)	Oestrogen levels in the first year after menarche and PA are positively associated with bone strength in young adulthood, such that hormone levels may modify human osteogenic responses to exercise.

De Vriendt 2012 Belgium/ European countries	Adols 12–17yrs from the Healthy Lifestyle in Europe by Nutrition in Adolescence study (HELENA). To examine the relationship between perceived stress and diet quality in European adolescents.	Cross-sectional data from adols from schools in five European cities (Ghent, Stockholm, Zaragoza, Athens and Vienna).	1.24h dietary recall diary over 2 days 2.Diet Quality Index for Adolescents (DQI-A) 3.Adolescent Stress Questionnaire. 4.Height 5.Weight 6.Pubertal stage (ax not detailed) 7.Parental education level 8.moderate-to-vigorous physical activity (MVPA) 9.sleep duration	704 adols; in both boys and girls, perceived stress was a significant independent negative predictor for their overall diet quality. This inverse relationship was observed for all dietary components, except for dietary diversity in boys, and it was unaltered when additionally adjusted for MVPA or sleep duration.

De Water 2013 Holland	Adols 11–16yrs. 1) To examine pubertal maturation and associations with levels of alcohol use, when controlling for age. Also, 2) relationships between hormones and alcohol use.	Cross-sectional study. Questionnaire data.	1.alcohol use 2.age 3.salivary sex steroid levels 4.Pubertal Development Scale (PDS) (SR)	1)797 Dutch adols 2)168 Dutch adols Advanced pubertal maturation is related to increased alcohol use in both boys and girls. Controlling for age, higher testosterone and estradiol levels correlated with the onset of alcohol use in boys. Higher estradiol levels were associated with larger quantity of alcohol use in boys. Correlations between sex steroids and alcohol use were not significant in girls.
Dornbusch 1981 USA	12–17yr old youths; dating, age and sexual maturation.	Survey data from US National Health Examination Survey.	1.dating (rather than sexual activity) 2.age 3.sexual development (physician Tanner ax) 4.social class 5.ethnicity	6,710 participants; Individual levels of sexual maturation add little to explain variation in dating after age has been taken into account. Social pressures determine onset of dating behaviour.

Drescher 2011 USA	Adols 10–17 yrs; sleep duration and obesity.	Cross-sectional study. Data from the Tucson Children' Assessment of Sleep Apnea study.	1.parent reported sleep score 2.BMIz score 3.screen time (in association with PA ax) 4.dietary and caffeine intake 5.exercise and sleep habits 6.anthropometic measures	319 participants; total sleep time was inversely related to BMIz score, Hispanic ethnicity, screen time and caffeine consumption. Results varied with age.
Duke 2014 Australia	Male adols 9–18yrs; effect of testosterone on behaviour and mood in adolescence.	SR; Human studies only; community studies involving mood and/or behavioural ax, plus testosterone level measurement.	1.timed testosterone measure (serum or saliva) 2.externalizing behaviours 3.alcohol and other drug use 4.self-image/social behaviours 5.mood/affect	27 publications reviewed. Only one longitudinal study. No consistent relationships observed.

Dumith 2012 USA	Adols at 11 and 15yrs; predictors of change in PA.	Cohort longitudinal study with 2 time points: 11 and 15yrs. Each data collection period lasted 8 months. Interviews and questionnaires to adols and mothers.	1.change in PA status (self-report) 2.amount of moderate-to-strenuous activity 3.skin colour 4.socio-economic level 5.maternal PA 6.time outdoors 7.fear of living in neighbourhood 8.BMI 9.Tanner stage 10.screen time	4120 adols. Maternal PA change associated with positive adol PA change; higher male maturation and later menarche in females were associated with positive PA change. Adols remained inactive if they were fearful of neighbourhood, and became inactive if they were of higher S-E status (males) or had more screen time (females).

Duncan 2007 USA	Adols 12–17yrs; factors affecting PA patterns.	Cohort sequential study from 3 age cohorts: 10, 12 and 14yrs. Data gather annually over 4 year period.	1.PA survey based on Youth Risk Behaviour Survey (self-report data) 2.Pedometer data 3.BMI 4.Pubertal Development Scale (self-report) 5.self-efficacy/barriers 6.parental/friend PA (self-report) 7.Parental/friend social support of adol (in relation to PA)	371 adols; PA activity declined significantly from 12 to 17yrs. Males had initial higher PA levels. Early maturing boys had greater initial PA levels, and greater decline.

Eisenmann & Wickel 2009	Adols; examining the biological correlates or determinants of PA in youth, and the physical activity phenotype.	A meta-review of reviews since 1998.	1.Age-Related decline in PA, and the Influence of biological maturity 2.Genetic factors influencing PA 3.Artificial selection experiments in animals 4.Individual or environmental issues 5.Non Exercise Activity Thermogenesis (NEAT) 6.Prenatal Environmental and Epigenetic influences	Hereditary factors contribute to the physical activity (and inactivity) phenotype and candidate genes are now being identified. Animal models indicate that maternal exposure to various environmental factors may alter offspring physical activity. Key brain structures and biomolecules involved in motivation, reward, and/or energy balance are also critical to understanding the biological basis of PA.

Erlandson 2011 Canada	Adols 8–15 yrs from the Saskatchewan Pediatric Bone Mineral Accrual Study. To examine PA from childhood to late adolescence when aligned on chronological and biological age.	Longitudinal design incorporating eight age cohorts. The cohorts were aged between 8 and 15 yr at study entry. 8 yrs of serial data collection.	1.chronological age 2.biological age (age at peak height velocity) 3.BMI 4.Physical Activity Questionnaire for Children (SR) 5.Physical Activity Questionnaire for Adolescents (SR)	187 adols. Physical activity decreased with increasing CA from late childhood into adolescence, with girls being less active than boys. Accounting for differences in the timing of biological maturity had little effect on tracking physical; maturity may be more important in physical activity participation in females than males.
Fawkner 2015 UK	Adol. females 11–12yrs; effect of maturation on PA, and effects of self-perception.	Longitudinal study; data collected at three 6 monthly intervals.	1.Physical Activity Questionnaire for Children 2.Pubertal Development Scale (self-report) 3. Children and Youth's Physical elf-Perception Profile 4.BMI 5.Skin fold thickness	208 female adols; Relatively more mature girls may be more active than their less mature peers.

Feinberg 2011 USA	Adols 9–18yrs; maturational sleep durations of NREM and REM sleep.	Longitudinal study; two cohorts of 9yrs and 12yrs at age of entry were followed up for 6yrs; twice yearly data collection on 4 consecutive nights; school and extended sleep (non-school) nights.	1.REM sleep duration 2.NREM sleep duration	67 adols; School night total sleep time declined with age, entirely produced by reducing NREM sleep. REM sleep increased slightly but significantly. During extended sleep, both durations extended; NREM did not change with age, whereas REM durations did increase significantly.

Feinberg 2006 USA	Examining the causal relationship between sexual maturation and decline in delta EEG of NREM sleep.	Longitudinal data; Cohorts of 9- and 12-year-old children (n 31, 38) were studied with in-home sleep EEG recordings at 6-mo intervals over 2 years.	1. Pubertal (Tanner) stage, 2. height, and weight	NREM delta power density (DPD) did not change significantly over ages 9–11 years, and its level did not differ in boys and girls. DPD declined by 25% between ages 12 and 14 years. Mixed effect analyses demonstrated that DPD was strongly related to age with Tanner stage, height, weight and body mass index controlled but that none of these measures of physical and sexual development was related to DPD with age controlled.
Frey 2009 Switzerland	Females 5–51yrs; to assess the relationship between puberty and the changes in sleep phase preferences during female maturation and adulthood.	Cross-sectional survey.	1.sleep preferences (weekdays and free days) using Munich Chronotype Questionnaire (SR) 2.age at menarche (SR)	1187 females; results show that in contrast to prepubertal children, adolescent females exhibit a striking progression in delaying their sleep phase preference until 5 years after menarche. Thereafter, the sleep phase preference switches to advancing

Gebremari-am 2012 Norway	Norwegian adols from the Health in Adolescents study. Mean age at baseline = 11.2 yrs. Change and correlates in PA, including impact of pubertal status.	Longitudinal study; data from 3 time points over 20 months.	1.PA levels (self-report) 2.pubertal stage (Pubertal Development Scale) 3.BMI 4.social support (from friends, parents, teachers) 5.environmental opportunity ax 6.social capital measure	885 students; enjoyment of PA, the effects of support and environmental factors remained moderately stable in the transition between childhood and adolescence. Small decreases in enjoyment of PA were noted for girls
Golley 2013 Australia	Young people 9–16yrs; part of Australian National Children's Nutrition and Physical Activity Survey. Sleep timing and diet quality, weight/adiposity.	Cross-sectional analysis of nationally representative survey data.	1.two day food intake 2.four day sleep-wake timings 3.anthropometric data inc BMIz, 4.PA levels	2,200 adolescents; late bed, late risers had higher BMI scores and lower diet quality, independent of sleep duration or activity level.

Graber & Sontag 2006 USA	Adol girls. To examine the psychological and social impacts of pubertal development on changes in girls' feelings about themselves (their bodies) and their sexuality.	Review and comparison of models that link puberty and sexuality e.g. models that indicate that sexual desires and behaviours are in part the result of brain development and physiological processes.	Puberty and: 1.body image 2.peer relationships 3.romantic relationships 4.emotional development 5.sexuality	Sexuality begins to develop more fully during puberty, develops extensively over adolescence, and is interconnected with changes in self and social context during this period. As such, sexuality is likely to have important connections to engagement in sexual behaviours and experiences, which in turn stimulate re-evaluation of beliefs and attitudes about one's sexuality.
Grassi 2006 Italy	Adols 14–18yrs; aerobic fitness and somatic growth.	Cross-sectional study.	1.$VO_{2\,max}$ 2.body mass 3.standing height 3.BMI	290 adols; aerobic fitness declined with age in both sexes. Decline greater in females. A negative association between BMI and $VO_{2\,max}$ was found in overweight adols. Almost all participants could be labelled as sedentary due to lack of PA.

Hagenauer 2013 USA	Adol. human and rodent studies. To examine the developmental forces driving adolescent sleep patterns using a cross species comparison.	A review of sleep patterns in human and laboratory animals.	1.homostatic 'sleep pressure' 2.circadian rhythm 3.sleep timing and architecture	Sleep parameters change during adolescents in a hormone-dependent manner; changes in the regulation of sleep by the circadian timekeeping system are also present, and both processes may be responsible for adolescent sleep patterns.
Hagenauer 2009 USA	Adol. human and animal studies	Review of sleep patterns in adolescent humans and animals.	1.homeostatic drive to sleep 2.circadian regulation of sleep 3.developmental changes	The delayed sleep phase in adolescence is a likely common phenomenon across mammals, not specific to humans.
Halpern 2007 USA	Adols under 15 years; Pubertal timing and risk behaviour, esp. sexual risk and substance use.	Longitudinal data; questionnaires from 'Add Health' study, 1994–1996.	1.Age, gender, race 2.Parental education 3.Perceived physical maturity (proxy for pubertal status) 4.Age of partner 5.Risk behaviour	4,118 participants. Advanced physical maturity associated with higher risk, esp. in relation to alcohol/substance use, and in girls with older partner.

Halpern 1998 USA	Adol. males 12–14 years at start of study. To examine the relationship between testosterone and sexual activity through more frequent data collection.	Longitudinal cohort study; 2–3 year follow-up. Questionnaires, interviews and hormone levels taken. Appears to be an extension of earlier research, as detailed in Halpern et al 1993.	1.monthly salivary testosterone levels 2.weekly behaviour checklist, including sexual activity 3.Tanner stage	127 adol. males. Over 80% prepubescent at start of study (by testosterone levels). Higher levels of salivary testosterone were associated with sexual activity initiation and more frequent coital and non coital activity.

Halpern 1997 USA	Post menarcheal adol females. To examine pubertal rise in testosterone and associations with subsequent increases in female sexual interest and activity, within the context of a social control variable.	Longitudinal study over 2-year period, involving questionnaires and interviews.	1.Sexual behaviour, ideation and motivation 2.religious attendance 3.Tanner stage (SR) 4.Testosterone levels (specifically timed blood samples)	200 female adols. Testosterone and changes in testosterone were significantly related to the timing of subsequent transition to first coitus for blacks and whites females. Frequency of attendance at religious services operated as a social control variable, and was found to moderate effects of testosterone on sexual transition.
Halpern 1993 USA	Adol males, 12–13 years. To examine if sexual activity is initiated and increases in relation to testosterone levels.	Longitudinal cohort study. Behavioural questionnaires and blood samples (for testosterone) collected every 6 months for 3 years.	1.bi-annual blood testosterone levels 2.bi-annual behaviour checklist, including sexual activity 3.Tanner stage	100 adol. males. Pubertal development is significantly related to sexual ideation, non-coital behaviour, and transition to sexual intercourse. Hormone levels did not predict changes in ideation or non-coital sexual activity over the 3 years of the study.

Harrison 2011 USA	Influence of genetic and environmental factors on weight and obesity through childhood and adolescence.	Review of other studies/findings, plus ecological model formulation.	Model includes 6 domains/levels: 1.Cellular 2.Child 3.Clan 4.Community 5.Country 6.Culture	Influences at cellular, individual (child), family (clan), community, country, and cultural levels are incorporated into the Six-Cs model.
Hinckers 2006 Germany	Adolescent cohort at age 16 from the Mannheim Study of Risk Children.	Prospective study; cohort data at one time-point.	1.average alcohol consumption over 6 months using Lifetime Drinking History Scale 2.Family Adversity Index 3.Externalizing behaviour 4.Blood samples for genotyping	243 adols. Lower response to alcohol was found amongst carriers of two long alleles of 5-HTT.

Irons 2012 USA	Adopted adolescents and young adults from The Sibling Interaction and Behavior Study (SIBS); to examine the effect of ALDH2 polymorphism upon drinking, and relationship to developmental stage and environmental context.	A prospective longitudinal study of sibling pairs, including both adopted and non-adopted adolescents, and their parent. Measures from 3 time points over 7 yrs (?)	1. peripheral blood or buccal swab for genotyping 2.structured interviews including Diagnostic and Statistical Manual of Mental Disorder questionnaire 3. modified version of the Substance Abuse Module 4.peer behaviour questionnaire	356 participants. Possession of the ALDH2 allele has been repeatedly shown to be associated with lower risk for alcohol dependence and reduced alcohol use. The protective effect of the ALDH2 allele increases over the course of adolescence and young adulthood and is modified by the environmental influence of parental alcohol use and misuse.

Jaszyna-Gasior 2009 USA	Adol girls 14–16yrs, participating in a smoking cessation trial. To explore the relationship between age of menarche, smoking and influence of weight concerns.	Cross-sectional study; data taken at one point from 12 week trial. Interviews and questionnaires.	1.age at menarche 2.smoking behaviour and history 3.Fagerstrom Test for Nicotine Dependence 4.Eating disorders module from the Diagnostic Interview for the Child and the Adolescent	71 females; significant relationship between age at menarche and age of onset of daily smoking; no significant associations with having weight concerns.
Johnson 2012 USA	Young adults 18–30yrs; To examine difference in skeletal maturity and stature from 0-18yrs in normal and overweight young adults.	Longitudinal study; annual data from 0–18yrs, plus data during young adulthood. Part of the Fels Longitudinal Study.	1.weight 2.height 3.skeletal-chronological age 4.BMI	521 young adults; height increased during puberty, with overweight or obese young adults being about 3cm taller at puberty than their normal weight counterparts. These differences diminished by age 18yrs, with no significant difference at that age. Overweight and obese adults were more advanced in terms of skeletal maturity throughout childhood, peaking during puberty.

Jurimae 2009 Estonia	Adol boys aged 10-16yrs; to assess the influence of regular physical activity on plasma ghrelin concentration in pre-pubertal and pubertal boys. In addition, the impact of ghrelin concentration on bone mineral density (BMD) was examined.	Controlled study with swimmers and non-swimming comparison group.	1.physical activity 2.ghrelin levels (blood assays) 3.Tanner pubertal stage (SR) 4.BMD (by DXR) 5.BMI 6.IGF-1 (Insulin-like Growth Factor) 7.VO_2 (activity levels)	56 adol. boys; ghrelin concentration decreased during puberty in physically inactive boys, while in regularly physically active boys it remained relatively unchanged. Ghrelin appears to be an important hormonal predictor for BMD in physically active boys, while BMD is mostly determined by IGF-I in physically inactive boys.

Katzmarzyk 2008 USA	Physical activity and obesity in children, typically 5–17yrs.	Review, plus summary statement and recommendations	Overweight/obesity, measured by: 1.skinfold thickness 2.weight for age 3.weight for height 4.body mass index (BMI) 5.ethnicity 6.genetic influences 7. Behavioural, social, and environmental determinants	In general, there is a negative relationship between measures of physical activity and adiposity in children. In addition, the available data suggest that high levels of PA reduce the likelihood of weight gain over time.
King 2010	To examine the influence of ghrelin and obestatin on appetite control, the regulation of energy, and physical activity in adolescence.	Review and discussion.	1.gherlin and obestatin levels and influence 2.eating behaviours 3.metabolic rates 4.physical activity	Gherlin and obestatin are associated with alterations in the drive to eat (i.e. hunger), eating behaviours and appetite regulation. Furthermore, there is some evidence that these peptides might also be associated with physical activity behaviours and metabolism.

Knowles 2009 UK	Adol. girls, 11–12yrs. To investigate the influence of maturation on physical self-perceptions and PA in early adol. girls.	Longitudinal study: two time points, 12 months apart.	1.Physical Activity Questionnaire for Children 2.Youth Physical Self-Perception Profile 3.Pubertal Development Scale 4.body mass, waist circumference, skinfold thickness	150 adol. girls; decrease on overall PA, not influenced by maturational status or physical characteristics. Physical self-perception partially accounted for this. Body mass was an important predictor of change.
Knutson 2005 USA	Adols 12–16yrs. To examine associations between growth and development stage and sleep.	Data from the National Longitudinal Study of Adolescent Health (data from 1994–96); 2 interviews, 1yr apart.	1.pubertal development (self-report: questions similar to Pubertal Development Scale) 2.height 3.sleep duration 4.insomnia 5.tiredness 6.insufficient sleep	Data from 2,339 adols. Females had increasing problems with sleep in relation to increasing development, but not males. Both genders had a negative association between sleep duration and development. No association between sleep and height velocity was noted.

Kohl & Hobbs (1998) USA	Review of evidence of potential determinants of physical activity in children and adolescents.	SR: methods of review not detailed.	1.physiological or developmental factors 2.environmental factors 3.psychological, social, demographic factors	A variety of factors are potential determinants of physical activity in children and adolescents. Interaction between these factors is likely. Correlations rather than true predictors are evident in the examined evidence.
Labbrozzi 2013 Italy	Early and mid-adol. girls aged 11 and 13yrs; to examine self-perception and motivation towards PA.	Cross-sectional study of two age cohorts.	1.BMI 2.Tanner stage 3.Physical Activity Enjoyment Scale (PACES) 4.Physical Self-Perception Questionnaire 5.Situational Intrinsic Motivation Scale	134 adol. girls; older girls displayed poorer physical perception, lower motivation and enjoyment of PA at 11yrs, more developed girls displayed poorer physical perception relating to body fat, self-concept, appearance, and lower PACES scores.

Laberge 2001 Canada	Adols 10–13yrs. (Part of larger longitudinal study). To examine the developmental changes of sleep patterns as a function of gender and puberty.	Longitudinal study over 3 yrs, with annual data collection.	1.sleep patterns and habits questionnaire, including sleep disturbances during the previous year 2. Pubertal Development Scale (self and maternal ax); twice yearly ax for 3 yrs	Results indicated that nocturnal sleep times decreased, bedtimes were delayed and differences between weekend and school day sleep schedules progressively increased with age. Girls had longer weekend time in bed and later weekend wake time than boys. Subjects with higher pubertal status showed longer weekend TIB and later weekend wake time.
Lantis 2009 USA	Adols 14–17 years; to examine associations between total sleep time and eating behaviours (hunger, satiety, cravings, calorie intake).	Cross-sectional study including a 7-day sleep-hunger-satiety diary.	1.sleep habit survey 2.BMI 3.Calorie and energy expenditure interviews 4.Food Craving Inventory (FCI-II) 5.7 day sleep-hunger-satiety diary	85 adolescents; age, gender and race were associated with hunger, satiety and cravings. Greater total food craving score was associated with increased daytime sleep.

Laucht 2009 Germany	Participants drawn from ‘Children at Risk’ study (birth-adulthood – same overall study as Blomeyer et al, 2013 and Buchmann et al, 2009); current data from age 19 years relating to genetic factors, adversity and alcohol consumption.	Epidemiological cohort study; current data from one time point (aged 19yrs).	1.genotype: 5-HTTLPR 2.Interview 3.45-day drink history, incl. total number of drinks and drink binging days 4.family adversity	Male adols with LL genotype 5-HTTLPR and adversity exhibited more hazardous drinking than those with S-allele, or without exposure to adversity.

Li 2011 USA and China	Adols from a Chinese Han population (Wuhan smoking Prevention Trial – av. age 12.6) and Caucasian adols living in California (Children's Health Study – mean age 10.2). Av. Follow-up 7.41 years. Role of genetic factors and smoking initiation	Longitudinal study	1.200-item survey, including baseline smoking behaviour, social and economic status etc 2.buccal cells for DNA extraction	2339 Chinese adols; 603 Caucasian adols. The calcyon neuron-specific vesicular protein gene (CALY) may influence smoking initiation in adol. females

Lumeng 2007 USA	Adols in 3rd and 6th grade (approx. 9 and 12yrs), from the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development; to test the independent associations of sleep duration and problems with overweight risk in children.	Longitudinal study; data from two time points within a larger/longer study.	1.sleep duration and problems (maternal report) from Children's Sleep Habits Questionnaire (CSHQ) 2.chaos at home (The CHAOS Scale) 3.quality of the home environment (Mid-Childhood Home Observation for Measurement of the Environment) 4.lax-parenting subscale score of the Raising Children Checklist 5.Child Behavior Checklist 6.BMI	785 adol. participants; shorter sleep duration in 6th grade was independently associated with a greater likelihood of overweight. Shorter sleep duration in 3rd grade was also independently associated with overweight in 6th grade, independent of the child's weight status in 3rd grade. Sleep problems were not associated with overweight.

Lytle 2011 USA	Adols 10–16yrs, from the Identifying Determinants of Eating and Activity (IDEA) study; to examine the relationship between weight-related variables and sleep variables.	Cross-sectional using questionnaires.	1.sleep questionnaire 2.BMI 3.energy intake (3 dietary recalls) 4.energy expenditure (Actigraph accelerometer) 5.Kandel–Davies scale (depression) 6. Pubertal Development Scale (SR)	349 adols and significant adults; Particularly for middle-school boys and girls, inadequate sleep is a risk factor for early adolescent obesity.
Machado Rodrigues 2010 Portugal	Adols 13–16yrs. To examine the contribution of somatic maturation and sex differences in sedentary behaviour and PA.	Cross-sectional study with participants divided into two groups, 13–14 and 15–16 years.	1.Actigraph accelerometer readings over five consecutive days 2.Percentage of predicted mature (adult) height (as maturity measure) 3.Weight 4.Chronological age	302 participants; males spent more time in moderate to vigorous PA and less time in sedentary behaviour than females. However, sex differences were attenuated when maturation was controlled; thus suggesting that maturity may play an important role in adolescent behaviours.

Maestu 2013 Estonia	Adol. boys 11–13yrs. To examine the association between the angiotensin I-converting enzyme (ACE) gene polymorphism and PA levels in boys at early pubertal stage.	Cross-sectional study.	1.Body composition by DXA 2. Tanner pubertal stage (professional ax) 3.cardiovascular fitness on cycle ergometer 4.7-day accelerometry measures 5. D or I allele presence (blood assays) 6.screen time (as proxy for sedentary activity)	261 boys. No ACE genotype or allele effect on higher PA levels (i.e. moderate and vigorous physical activity), which are considered as the most important activity levels related to cardiovascular health risks in children. In contrast, carrying the I allele was instead related to sedentary behaviour. Carriers of the D allele had significantly higher light physical activity levels.
Martin 2002 USA	Early and mid-adols 11–14yrs; to examine the relationship between substance use, sensation seeking and pubertal development.	Cross-sectional study. Questionnaires and standardized measures used.	1.Sensation Seeking Scale 2.Pubertal Development Scale (adol and parent) 3. nicotine, alcohol & marijuana use (self-report)	208 adols; sensation seeking was higher in males and females who reported alcohol and nicotine use, and higher in males who used marijuana. Sensation seeking was positively associated with pubertal development in both sexes, even when controlling for age, and mediated the relationship between pubertal development and drug use.

Maume 2013 USA	Teens 12–15 years; part of the Study of Early Child Care and Youth Development. Examined sleep patterns, social ties and developmental stage.	Longitudinal study from birth to 15yrs; data for this analysis from two time points: 12yrs and 15yrs.	1.sleep habits 2.parental support 3.school/peer support 4.Time use (TV/IT use) 5.Delayed phase preference (sleep-wake patterns) (1-5 All self-report) 6.Tanner stage (prof ax)	974 participants; social relational factors out-perform developmental factors in determining youths' sleep patterns. Stressful social ties, excess school homework, TV and computer use, and family poverty, disrupt sleep in general. School, peer and family support improved duration and quality of sleep.
McCabe 2002 Australian	Adol. teens; examining the impact of pubertal development, peer relationships, and media pressures on dissatisfaction and behaviours.	Cross-sectional study with two cohorts from grades 7 & 9 (aged approx. 12 and 15yrs). SR questionnaires were used.	1.pubertal development (SR) 2.media and peer influence 3.body dissatisfaction 4.weight control	1,185 adols; girls were more likely to adopt strategies to lose weight, boys to increase muscle, but not weight. Main predictor was puberty for boys; girls were influenced by puberty and media to lose weight. In older girls predictors of body dissatisfaction and desire to increase muscle tone were perceived popularity with opposite sex.

McCartney 2009 USA	Girls at Tanner stage 1–2, and 3–5; to examine the characteristics of lutenising hormone during puberty.	Cross-sectional study	1.Lutenising hormone blood levels at 10 min intervals during overnight period 2.BMI	13 girls at Tanner stage 1–2 (8 non-obese, 5 obese); 44 girls at Tanner stage 3–5 (32 non-obese, and 12 obese).
Miller 2014	Children and adols 7–18yrs, participants in several studies of eating behaviour and obesity conducted at the National Institute of Child Health and Human Development. To examine associations between leptin and loss of control (LOC) eating.	Cross-sectional with convenience sample.	1.Serum leptin 2.Adiposity (dual-energy X-ray absorptiometry or air displacement plethysmography) 3.LOC eating (Eating Disorder Examination interviews) 4.BMI 5.Tanner Scale (prof ax)	506 lean and obese adols; Reports of LOC eating were associated with higher fasting leptin in youth, beyond the contributions of body weight. The relationship between LOC eating and leptin appeared to be significant for females only.

Moore 2014 USA	Adol. girls from the National Longitudinal Study of Adol. health. Pubertal timing, sexual behaviour, and genetic influences.	Sibling-comparison study, to establish genetic factors. Longitudinal: 4 time-points over 14 years.	1.age at menarche 2.perceived pubertal timing 3.age at first intercourse 4.dating and sexual activity	923 sibling pairs. Shared genetic pathways influencing age at menarche and perceived pubertal timing, predicted age of first sex. Genetic factors relating only to perceived pubertal timing predicted dating, romantic and non-romantic sex.
Moss 1999 USA	Pre-pubertal and adol. boys 10–12yrs initially; to examine salivary cortisol under-reactivity and substance use.	Longitudinal study of prepubescent boys, 10–12 years, with follow-up after 4 years.	1.paternal drug and alcohol use 2.salivary cortisol levels 3.adolescent substance use	298 participants of high and low-average risk. Decreased salivary cortisol response to an anticipated stressor was lower in sons with substance use father, and was associated with regular cigarette and marijuana use.

Murdey 2004 UK	Adols in 3 age groups: 10–11yrs; 12–13yrs and 14–15. To investigate the effects of age, puberty, gender, body composition, and sleep on sedentary behaviour.	Phase 1 of a longitudinal study measuring changes in adolescents' free-time behaviour over an 18-month period.	1.BMI 2.percentage body fat 3.sedentary behaviour 4.sleep time 5.body image (using the Children's Physical Self-Perception Profile) 6.pubertal status (SR)	119 participants; after controlling for sleep time, no differences in sedentary time were seen for puberty onset or increased pubertal development. Correlations between pubertal status, body composition, and body image were stronger in girls than in boys. Correlations between body image and sedentary behaviour were not strong enough to infer behavioural choice differences.
Muratoa & Araki 1993 Japan	Adol. girls 9–15yrs.To examine the effects of age, body weight, height, hours of sleep, and sleep conditions on the onset of menarche.	Cross-sectional design; questionnaire data.	1.Age, body weight, height 2.hours of sleep, sleep conditions 3.presence or absence of menarche All data from SR questionnaire.	254 adol. girls; body weight, height, and hours of sleep were significantly related to the presence/ absence of menarche while controlling for the effects of age and sleep conditions. There was a time lag of about 2 years between the abrupt decrease in hours of sleep and the maximal increase in the menarcheal per cent.

Olds 2011	Free living Australian adols aged 9–16yrs. To examine relationships between sleep patterns and activity.	Observational cross-sectional study involving use of time interviews and pedometers.	1.sleep-wake pattern groups: early-bed/early-rise; early-bed/late-rise; late-bed/early-rise; late-bed/late-rise. 2.Use of time (screen time, physical activity, and study-related time). Multimedia Activity Recall scale for Children and Adults used. Objective physical activity recorded using pedometer for 7 days, and number of daily steps averaged 3.sociodemographic characteristics 4.weight status: Height, body mass, BMI and waist girth	2,200 adols; late-bed/late-risers experienced 48 min/d more screen time and 27 min less moderate-to-vigorous physical activity than early-bed/early-risers in spite of similar sleep durations. late-bed/late-risers also had higher BMi z-scores, and were 1.47 times more likely to be overweight or obese than early-bed/early-rise adolescents; late-bed/late-rise adolescents were more likely to come from poorer household.

Randler 2009 Germany	Adols 11–20yrs; to assess the change in sleep using measurements for chronotype, pubertal development, and parental monitoring.	Cross-sectional study using questionnaires with SR measures and validated tools.	1.Composite Scale of Morningness 2.midpoint of time in bed (calculated from rise and bedtimes) 3.Pubertal Development Scale (SR) 4.setting of bedtime (e.g. self/parental) 5.Sleep onset latency 6.sleep duration (weekdays, weekends, and average)	784 adols; Older adolescents become more evening oriented, sleep less, and have later rise and bedtimes. Age was the only significant predictor of chronotype, whereas age, pubertal status, and parental monitoring significantly contributed to bedtime during the week and sleep length on weekdays.

Reither 2014 USA	Adols grades 7–12 (approx. 12–17yrs); To examine associations between sleep durations and BMI. Part of National Longitudinal Study of Adolescent Health.	Longitudinal study, but pooling of data from two phases, so essentially a cross-sectional approach.	1.sleep duration 2.BMI 3.physical development (onset of menses in females, or voice changes in males) All data based on SR.	30,133 adols; no evidence that sleep duration contributes substantially to ethnic disparities in BMI. Sleep duration is negatively associated with BMI among White, Hispanic and Asian boys, positively associated with BMI among Black girls and is not related to BMI among Black boys or girls from White, Hispanic or Asian ethnic groups.
Reynolds 2007 USA	Males 12–22yrs; to determine whether testosterone level and sexual maturation in boys biased non-normative behaviour potentially leading to substance use disorders (excluding nicotine and caffeine use disorders),	Prospective study starting at age 10–12yrs; subsequent follow-up evaluations at 12 to 14yrs, 16, 19, and 22 years of age (5 data collection points in total).	1.Blood testosterone levels 2.Tanner stage (professional ax) 3. Social Potency Scale 4.Peer Delinquency Scale 5.Perception of Problem Behaviors Scale 6.Drug Use Screening Inventory 7.Structured Clinical Interview for Disorders	179 adols; testosterone predicted social potency, approval of aggressive/ antisocial behaviour; these factors and deviant peer affiliations predicted illicit drug use by late adolescence that in turn predicted SUD in young adulthood.

Rinker 2011	Adol. and adult rats. To examine if periadolescent nicotine exposure influences the aversive effects of alcohol.	Male Sprague Dawley rats were exposed to either saline or nicotine.	1.blood alcohol concentration 2.rectal temperature 3.locomotor activity	64 rats (experiment and control); Results suggest that nicotine may alter the aversive and physiological effects of alcohol, regardless of the age at which exposure occurs, possibly increasing its overall reinforcing value and making it more likely to be consumed.
Rutters F 2011 Holland	Children from birth to 17yrs; to investigate the relationship between a SNP of the FTO gene (rs9939609) and obesity-related characteristics during childhood and puberty.	Longitudinal study from birth to 17yrs; this part of study from 12–17yrs.	1.body composition 2.leptin concentrations 3.physical activity, 4.hours watching television 5.attitude toward eating 6.parental characteristics 7.genomic DNA from blood leukocytes	101 adols; the FTO A allele (rs9939609) is associated with higher BMI, fat mass index, and leptin concentrations from the age of 12yr, whereas the associations show a dip at ages 13–14yr and become stronger at age 17 yr.

Rutters 2010 Holland	Adols 7–16yrs; to investigate associations between sleep duration and body-weight.	Longitudinal data from adols yearly data collection over a 9yr period.	1.Leptin concentrations 2.BMI 3.PA (Baecke questionnaire) 4.TV hours 5.sleep duration (SR) 6. polymorphisms of the FTO gene (rs9939609 7.Tanner stage 8. body composition using the deuterium dilution technique 9.parental BMI	98 adols; with progressive Tanner stages, BMI increases and sleep duration decreases in an interrelated way independent of possible confounders.

Ruttle 2013 USA	Adols 11–18yrs; to examine concurrent (i.e., measured at the same point in time) and longitudinal (i.e., using earlier cortisol measures to predict later body mass index [BMI]) associations between diurnal cortisol and BMI across adolescence.	Longitudinal study, with measurements taken at 4 time points: age 11, 13,15 and 18yrs.	1.salivary (diurnal) cortisol measured over 3 days 2.BMI (some SR measures used) 3.Tanner stage (SR and parental ax) 4.Pubertal Developmental Scale (mother's ax) 4.MacArthur Health and Behavior Questionnaire	Blunted patterns of adolescent cortisol were associated with increased measures of BMI across adolescence. Additional analyses using BMI categories revealed that findings may be extended beyond BMI scores to predictions of obesity.
Sadeh 2009 Israel	Adols 10–11 yrs at start of study; to assess the links between sleep and pubertal development.	Longitudinal study. 3 consecutive annual assessments of sleep and pubertal development. Sleep was assessed using a week of home actigraphy.	1.Petersen's Pubertal Development Scale (SR) 2.Sexual Maturation Scale (SMS) to assess pubertal development (SR) 3.Actigraphy to assess naturalistic sleep pattern	94 adols; after controlling for age, significant relationships found between sleep onset, true sleep time, and number of night wakings at Time 1, and pubertal ratings at Time 2, and pubertal changes from Time 1 to Time 2.

Sharma & Kaur 2014 India	Adol girls, aged 11–18 yrs. To explore the role of TAS2R38 locus in taste choices, adolescent growth trend for body height, weight and fat patterning among girls.	Cross-sectional data.	1.food consumption pattern over 24hrs (unstructured questionnaire) 2.4-point hedonic preference scale 3.stature (cm) 4.body weight (kg) 5.four skin-folds (mm) (triceps, subscapular, suprailiac and calf) 6.BMI 7.Body fat (OMRON Body Fat Analyser) 8.Basal metabolic rate 9.Phenylthiocarba-mide (PTC) tasting ability (serial dilution method)	210 girls; more sensitive PTC tasters had a low preference for raw vegetables and bitter tasting foods, and higher preference for sweet-tasting foods. PTC tasters overtook their PTC non-taster counterparts from age 14–16 years in having higher mean average skinfold, percentage body fat, fat mass index and fat-free mass index.

Sherar 2009 Canada	Adol. girls 8–16yrs. To describe the PA levels and perceived barriers to PA of adolescent girls grouped by school grade and maturity status.	Cross-sectional study using ecological approach; different age groups across schools within same area.	1.Actical accelerometer readings (for 7 days) 2.semistructured, open-ended questionnaire on perceived barriers to PA over 7 days 3. Predicted age at peak height velocity 4.Age at menarche 5.BMI 6.Skinfold thickness at five sites of the body (subscapular, triceps, biceps, iliac crest, and medial calf) to assess body fat	221 adol. girls. Daily mins spent in moderate to vigorous PA decreased by 40% between grades 4 and 10 (8–16yrs). Within grade groupings, no differences in PA were found between early and late maturing girls. Grade 4 to 6 (8–10yrs) participants cited more interpersonal/social barriers. Grade 9 to 10 girls (15–16yrs) cited more institutional barriers to PA (e.g. school programmes).

Sherar 2010 UK, Canada, USA	SR examining the relationship between timing of biological maturity during adolescence and PA.	Systematic review.	1.biological maturity 2.PA 3.chronological age 4.ethnicity 5.Tempo 6.sociological factors	Results are generally inconsistent among studies, partly due to variety in ax of biological maturity status and whether it is SR or clinically assessed; methods used to create maturity groups can vary; maturity homogeneity may not be present; small sample sizes are also used.
Shochat 2014 Israel	Adols, nominally 10–19yrs; to explore the consequences of inadequate sleep in adolescence on health outcomes.	Systematic review of descriptive evidence based on prospective and cross-sectional investigations.	PubMed and PsycNET (which is inclusive of PsycARTICLES and PsycINFO) electronic databases, covering all publications up to December 2012.	76 articles included in review. Results indicate that inadequate sleep is associated with negative outcomes in several areas of health and functioning, including somatic and psychosocial health, school performance and risk taking behaviour.

Simon 2003 UK	Adols in first yr of secondary school (11–12yrs). To examine the associations between puberty and three important health behaviours (smoking, food intake and exercise) and relations with stress and psychological difficulties.	Cross-sectional data from longitudinal (5yr) Health and Behaviours in Teenagers Study (HABITS).	1.self-report questionnaire on smoking, diet, exercise, body image, pubertal development, stress, psychological health, and personality 2.salivary cotinine levels 3.height, weight, and waist circumference 4.BMI 4.Pubertal Development Scale (SR)	4320 students; more pubertally advanced girls had a greater likelihood of having tried smoking, and experiencing more stress, but not more psychological difficulties. More pubertally advanced boys had a greater likelihood of having tried smoking, a higher intake of high-fat food and higher levels of exercise. No associations between puberty and either stress or psychological difficulties in boys.

Sisk 2013 USA	Influence of hormones on behaviour during puberty and adolescence.	Editorial review of 25 papers on the interplay between hormones, brain, and experience/ Behaviour.	Various hormonal and behavioural outcomes.	Our tools are still relatively crude for differentiating in human beings mechanisms that account for links between behaviour and hormones or pubertal stage, e.g. whether these links reflect hormonally mediated permanent changes to brain organization, or the activational effects of hormones that are influenced by genes and/or experience.

Skidmore 2013 NZ	Adols 15–18yrs. To investigate relationships between sleep duration and multiple body composition measures in older adolescents and to investigate if these relationships differ between boys and girls.	Cross-sectional survey.	1.height and weight 2.fat mass index (FMI) and fat-free mass index (FFMI) 3.waist circumference and waist-to-height ratio (WHtR) 4.ethnicity 5.deprivation 6.number of screens in the bedroom 7.fruit and vegetable consumption 8.sleep duration	685 adols; no significant relationships were seen between sleep duration and any body composition measure but significant sex interactions were seen. An hour increase in average nightly sleep duration in boys only was associated with decreases of 1.2% for WC, 0.9% for WHtR, 4.5% for FMI and 1.4% for FFMI. Similar results were seen for weekday and weekend night sleep duration.
Smith 1985 USA	To examine pubertal development effects on sexual behaviour, to determine which are socially motivated and effects which are attributed to biological motivation.	Adols 14–17yrs. Cross-sectional data from a longitudinal study on early adolescent sexual behaviour.	1.Guttman-type scale of sexual behaviour (self + friends) 2.Tanner staging (self ax and interviewer ax)	The biosocial model indicates that a simultaneous consideration of pubertal development and friend's behaviour provides a different and clearer picture of the process than examination of the effects separately.

Spear 2004 USA	Adolescents and alcohol use.	Review of literature relating to adol alcohol exposure, both in humans and rodents.	Various outcomes relating to alcohol use, behaviour and physical effects.	Rodent research has indicated that adolescents are more sensitive to alcohol effects on brain plasticity; adols are also more insensitive to cues that may moderate alcohol intake. Neuorocognitive deficits may be apparent years after exposure to excess alcohol; however, some neural changes are evident prior to alcohol exposure.

Stanis & Andersen 2014 USA	Review of factors that influence vulnerability to addiction, including developmental stage, exposure to early life adversity (ranging from abuse, neglect, and bullying), drug exposure, and genetic pre-disposition, impact the development of relevant systems.	Literature review.	1.developmental stage 2.exposure to early life adversity (ranging from abuse, neglect, and bullying) 3.drug exposure 4.genetic predisposition 5.impact on development	A considerable amount is known about the functional neuroanatomy and/or pharmacology of risky behaviours based on clinical and pre-clinical studies, but relatively little has been directly translated to reduce their impact on addiction in high-risk children or teenagers.

Thompson 2003 Canada	Adols 9–18yrs. To investigate whether observed differences in physical activity levels in boys and girls are confounded by biological age.	Longitudinal study, with biannual or triannual data collection over 7 yrs.	1.physical activity questionnaire for children (PAQ-C) (SR) 2.chronological age 2.biological age: age at peak height velocity 3.Body mass	138 adols; level of physical activity decreased with increasing chronological age in both sexes. There were no sex differences in the longitudinal pattern of physical activity when the confounding effects of biological age were controlled except at 3yr before peak height velocity.
Udry 1985 USA	Adol boys 12–14yrs. To examine hormonal and social effects on adolescent male sexual behaviour	Cross-sectional study.	1.serum hormone assays 2.questionnaire data on sexual motivation and behaviour 3.Tanner pubertal stage (SR) 4.age	102 boys; free testosterone was a strong predictor of sexual motivation and behaviour, with no additional contribution of other hormones. Including measures of pubertal development and age indicated no additional effects.

Varlinskaya 2013 USA	To examine pubertal-related changes and adolescent- or adult-typical behaviours.	Literature review of laboratory animals (rodents) studies.	1.alcohol intake/ preference 2.gonadal hormones 3.novelty-seeking behaviours 4.gender 5.pubertal stage	Data suggest surprisingly modest influences of gonadal hormones on alcohol intake, alcohol preference and novelty-directed behaviours. Gonadectomy in males (but not females) increased ethanol intake in adulthood following surgery either pre-pubertally or in adulthood, with these increases in intake largely reversed by testosterone replacement in adulthood.

Vermeersch 2008 Belgium	Adol. boys, 14–15yrs. To examine the influence aggressive risk-taking and/or non-aggressive risk-taking behaviour and the relationship with pubertal development and peer affiliations.	Part of ADORISK, a larger study on the social and biological determinants of the sex gap in adolescent risk taking. Cross-sectional data reported in this paper.	1.Serum levels of testosterone and estradiol 2. Risk taking (SR questionnaire) 3.Peer associations/ behaviours 4.Tanner stage (physician ax) 5.Height 6.Body fat % 7.BP and heart rate 8.Grip strength 9.Waist to hip ratio	301 adolescent boys; individuals with higher levels of testosterone have friends that are more involved in risk taking; their influence contributes to increased levels of risk taking. Results indicate that hormones may influence the development of affiliations with risk-taking peers, a factor which is crucial in understanding adolescent behaviours.
Vetter-O'Hagen 2012 USA	Rat study, examining pubertal timing, hormone levels, genital development, and associations with responses to novelty.	Cross-sectional study, with data collected at 7 time points.	1.gonadal hormone and cortisol levels from blood samples 2.time spent with free-choice novelty (cotton wool ball) 3.age 4.weight	164 male and female rats. Results suggest that peaks in novelty seeking behaviour during adolescence was not notably puberty dependent in this rat population.

Warren & Brooks-Gunn 1989 USA	Adolescent white girls 11–13 yrs. To study the relationship among behaviour, mood, pubertal development, hormonal levels, and psychological functioning.	Cross-sectional study. Girls were recruited from a larger group of girls participating in a study of female adolescent biopsychosocial development.	1.Tanner stage (prof ax) 2.Blood hormonal assays 3. The Youth Behavior Profile 4. The Self Image Questionnaire for Young Adolescents 5. scale for interest and participation in sport 6. Depressive mood (maternal ax)	100 girls. No significant mood or behaviour changes were found as a function of pubertal stage, controlling for age effects, except for a decrease in interest in sports. The hormonal stages revealed a significant curvilinear trend for depressive affect.

Waylen & Wolke 2004 UK	To examine the biological and social factors that occur at puberty, in an attempt to explain when this transition may become problematic.	Literature review; methods not specified.	1.pubertal stage and timing 2.age 3.substance use 4.mental health/mood 5.social factors	Early pubertal onset in boys is likely to have beneficial effects; in girls precocious pubertal timing may have a negative impact on body-image, affect (or emotional wellbeing) and sex-role expectations. Biological and genetic factors may interact with social factors (e.g. peers, parenting style, neighbourhood) making adolescence either an adaptive or a challenging transition.
Wickel 2009 USA	Adols 9–14yrs; to examine physical activity levels among early, average, and late maturing boys and girls.	Secondary analysis of data that were originally collected to examine the reliability and validity of the Youth Media Campaign Longitudinal Survey.	1.Actigraph accelerometer over 7 consecutive days 2.Years from peak height velocity (as measure of maturity) 3.BMI	161 adols; Levels of moderate-to-vigorous PA were similar between early, average, and late maturing boys and girls after adjusting for differences in chronological age. Levels of MVPA progressively declined across chronological age in boys and girls; boys had higher levels than girls. When aligned according to biological age, gender-related differences did not exist.

Windle 2009 USA	Adols 10–15yrs. To examine nonspecific and alcohol-specific factors that put adolescents at risk for, or which protect them from, early alcohol use and its associated problems.	Review and discussion: methods not specified.	1.risk factors: specific and nonspecific 2.protective factors 3.alcohol use	Nonspecific risk factors include certain temperamental and personality traits, family factors, and non-normative development. Nonspecific protective factors include certain temperamental characteristics, religiosity, and parenting factors (e.g. parental nurturance and monitoring). Among the most influential alcohol-specific risk and protective factors are a family history of alcoholism and the influences of siblings and peers, all of which shape an adolescent's expectancies about the effects of alcohol, which in turn help determine alcohol use behaviours.

Zimmer-Gembeck & Collins 2008 USA	Adols 16–26 yrs. To determine sexual partnering from age 16–26yrs, and to test whether biological and social factors influenced these growth patterns.	Longitudinal data gathered over 26yrs.	1.SR number of sexual partners from age 16 onwards 2.Physical maturity at 13yrs (observer ax) 3.Frequency of alcohol use at age 16yrs (SR) 4.Romantic relationship history	176 adols; adolescents had accumulated a higher number of sexual partners by age 16 years when they looked older, drank alcohol more frequently, and were more involved with dating in early to middle adolescence. Male gender was associated with accumulation of sexual partners more rapidly between ages 16 and 26 years; little indication that the accumulation of different sexual partners had begun to slow by age 26 for the average participant.

Zimmer-Gembeck &Helfand 2008 USA	Adols <15yrs to >18yrs. Review; to provide a summary of what is known about the factors that precede and covary with the onset of adolescent sexual intercourse.	Analysis of findings from 35 longitudinal studies relating to the onset of heterosexual intercourse.	1.Age at first intercourse 2.Gender and race/ethnicity 3.Pubertal and physical maturation 4.Behaviours and attitudes (e.g. drug/alcohol use, delinquency etc) 5.Religious behaviour and attitudes 6.Mental health 7.Self-Esteem, confidence, and autonomy 8.Parental factors 9.Peer factors	35 longitudinal studies. When studies were organized by age of participants, the onset of intercourse was more strongly associated with alcohol use, delinquency, school problems and (for girls) depressive symptoms following sexual intercourse by age 15 than in later years.

Abbreviations: SR = systematic review; MA = meta-analysis; Fr = further research; ax = assessed; Q=questionnaire; adols = adolescence/ts; PA = physical activity; HCP = healthcare practitioners; PFC = prefrontal cortex; S-E = socio-economic; SR = self-report.