Journal of Health Monitoring

Influencing factors of obesity in school-age children and adolescents – A systematic review of the literature in the context of obesity monitoring
Influencing factors of obesity in school-age children and adolescents –
A systematic review of the literature in the context of obesity monitoring

Abstract

Around 15% of children and adolescents in Germany are overweight or obese. To support the planning, implementation and evaluation of preventive activities, the Robert Koch Institute (RKI) has developed a population-wide monitoring of influencing factors relevant to the development of obesity during childhood (AdiMon). AdiMon is a web-based indicator system providing population-wide meaningful and regularly updated data on factors that influence obesity in kindergarten-age girls and boys (0- to 6-years-old). Towards the end of 2020, the RKI will expand the indicator system to also cover the 7- to 17-year-old age group. To this end, a systematic review of the literature was conducted, a process which served to identify over 80 relevant factors that influence the development of obesity. These factors have been attributed to the categories behaviour, environment, biology, pre- and postnatal, psychosocial factors and context. Compared to a previous literature review for kindergarten-age children, around one tenth of the influencing factors now identified are new, including ‘peer group influences’ and ‘bullying’. As the results highlight, an array of influencing factors must be considered when expanding the monitoring system, ranging from individual health behaviour to the social framework conditions and environmental factors.

1. Introduction

Obesity is considered one of the key public health challenges of our time. Around 15% of children and adolescents in Germany are overweight, approximately 6% are obese [1]. Frequently, obese children and adolescents are also likely to become overweight or obese adults [2]. Being overweight or obese during childhood and adolescence can already cause health problems, with potentially severe health implications later in life [3]. Adult-age obesity is related to metabolic disorders and cardiovascular diseases, certain types of cancer and increased mortality rates [4]. A positive energy balance (taking up more energy than one requires) and biological influencing factors cannot solely explain obesity. Rather, the condition results from a complex interplay between numerous factors [5]. Individual genetic dispositions interact with an environment that has undergone considerable change over the last century and which, in industrialised nations, is characterised for example by a general availability of energy-rich foods. The settings in which individuals live, such as family, school and the community, are themselves influenced by the social, economic and political framework conditions. Key risk and protective factors, such as a health-promoting lifestyle, are
Influencing factors of obesity in school-age children and adolescents

acquired during early childhood, meaning that the settings a child grows up in can either reinforce or reduce the influence of such factors. Preventing obesity during childhood and adolescence is therefore of particular importance [6]. To stop the spread of obesity, the World Health Organization (WHO) recommends broad monitoring [7]. Monitoring systems can play a vital role in the planning, implementation and evaluation of prevention measures. Against this backdrop, the Federal Ministry of Health (BMG) has funded the AdiMon project at the Robert Koch Institute (RKI) to develop a population-wide monitoring of factors that influence obesity at childhood age (AdiMon). AdiMon is an web-based indicator system that provides population-wide meaningful and regularly updated data on factors that influence obesity at kindergarten age (0- to 6-years-old) [8, 9]. To describe the diverse set of factors that influence obesity, numerous sources of data were used, and meaningful indicators were developed. These were put into scientific context and published in concise fact sheets.

Beyond kindergarten, school age is a further key stage for the prevention of obesity. The prevalence of obesity among school-age boys and girls increases significantly. While 3.2% of 3- to 6-year old girls and 1.0% of boys are obese, for 14- to 17-year-old adolescents the figures are 7.7% (girls) and 9.2% (boys) [1]. Yet it is not only the prevalences of obesity that increase at school age; children and adolescents who are obese at school age are also more frequently obese as adults than children who are obese in kindergarten [10, 11]. School entry age is therefore considered a critical moment for the manifestation of obesity among children and adolescents. Against this backdrop, it is important to focus on the causes and spread of obesity among girls and boys at school age. By the end of 2020, we will therefore have expanded the indicator system to also cover the 7- to 17-year-old group. For this age group, the school setting is a key factor whose importance is increasing with the spread of all-day schools [12]. Entering school leads to great changes in the lives of children. With primary school, children’s everyday family routines become fundamentally restructured and demands on children increase, e.g. the need to be punctual and sit all day [13]. Furthermore, adolescence is a life phase characterised by numerous changes and challenges. During the biological process of development, the puberty, adolescent’s bodies undergo physiological and hormonal changes that they must confront. At the psychosocial level, the step from childhood to adolescence is characterised by the development of a more individual personality structure and people’s ever greater independence in their social environment [13]. For adolescents, the role played by peers regarding health behaviour increases in a phase where they are becoming ever more independent of their parents [14, 15]. To take account of this special phase in life, and to expand the indicator system, a systematic review of the literature to detect relevant influencing factors for obesity in school-age girls and boys was conducted. In the following, we present and discuss the methodological approach that was applied in the literature review, as well as the results. The latter provided us with a basis to expand the current monitoring system, because so far systematically compiled data on the causes and levels of obesity among school-age girls and boys in Germany had not been available.
2. Methodology

This systematic review of the literature was conducted in December 2018 in the Scopus, PubMed and Embase databases, the Web of Science and the Cochrane Library. Systematic reviews published between 2006 and 2018 were taken into account. The search string was built on the terminological categories influencing factor (determinants, causes, correlates, predictors, factors, origins, etiology, and understanding), obesity (obesity, adiposity) and target group (child, youth, adolescent). By using Boolean operators, keywords and wildcards, a database conforming combination of the three categories was created, whereby searches were limited to the titles and abstracts of publications.

After removing duplicates, the titles and abstracts were reviewed and the full texts read. Articles were excluded which were (1) not systematic reviews; (2) conference contributions; or (3) systematic reviews on measures and interventions. Further exclusion criteria were (4) no relevance of the influencing factors in Germany (for example an analysis of the role played by socioeconomic status in developing countries); (5) no relevance of an influencing factor for the population as a whole (such as rare genetic diseases); (6) lacking relevance of an influencing factor for the 7- to 17-year-old age group; and (7) no obesity relevant outcome. Furthermore, when (8) articles were published in non-covered languages (all languages except for German, English, Spanish and Portuguese), or (9) when the full text of an article was not available, the corresponding publications were also excluded.

The influencing factors identified in the reviews were inserted into a table matrix and differentiated by influencing area. The entire process was conducted as a dual control process. The literature was reviewed and influencing factors identified independently by two researchers. When cross-checking resulted in differences in the identified influencing factors, these were discussed together with a third researcher until consensus was achieved.

For the identified influencing factors, the following step consisted in evaluating the evidence provided. Information on the methodology applied and the results of the studies considered by the reviews was therefore gathered (Figure 1). Three levels of evidence were distinguished: convincing, sufficient and insufficient. Influencing factors were excluded if in the majority of studies on which reviews were based (at least three studies), no indication could be provided for a relationship with the development of obesity during childhood and adolescence. Influencing factors with only insufficient evidence were nonetheless included to take into account more recent research results with fewer studies. The influencing factors identified by the literature review

| Convincing evidence (A): | The majority of case-control, intervention or cohort studies considered by the reviews point in one direction (at least three studies). |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Sufficient evidence (B): | The majority of cross-sectional studies considered by the reviews point in one direction (at least three studies). |
| Insufficient evidence (C): | The studies considered by the reviews provide inconsistent results, or there were only few studies regarding a particular influencing factor. |
Influencing factors of obesity in school-age children and adolescents

were discussed during a workshop in May 2019 with external experts from public health practice, politics and science, and consolidated and evaluated with regard to their relevance for the prevention of obesity.

While the AdiMon system of indicators does consider measures and interventions relevant to the field of obesity, for methodological reasons these were not part of this literature review, because reviews on influencing factors and interventions appeared to require different search strategies. Correspondingly, over the course of the project, a further literature review will therefore be conducted. It will provide information on the scientific evidence regarding measures and interventions relevant to obesity at the individual, setting and population level.

3. Results

The described literature review provided 2,959 hits, of which 280 fulfilled our inclusion criteria (Figure 2). A total of 80 influencing factors that are relevant to the development of obesity in school-age girls and boys in Germany were identified. Around one tenth of these are factors that were not identified by the AdiMon project review conducted for kindergarten-age children [9].

Compared to a previous literature review for kindergarten-age children conducted in the context of the AdiMon project, the number of identified influencing factors has increased by around one tenth.
The detected influencing factors were categorised according to the areas behaviour, environment, biology, pre- and postnatal, psychosocial factors and context shown in the simplified cause and effect model (Figure 3). The model was developed during the initial phases of obesity monitoring for kindergarten-age children [8]. It shows that behavioural (such as physical activity) and biological factors (such as genetic disposition) are relevant for the development of obesity. Also prenatal factors (such as weight gain by mothers during pregnancy) and factors during early childhood (such as breastfeeding) influence the development of obesity. Furthermore, psychosocial factors (such as how parents perceive the weight of their children) can impact the development of obesity during childhood and adolescence. Environmental factors are mostly related to the settings a child grows up in, such as family, neighbourhood or kindergarten (for example the food offered there). The mentioned influencing factors are themselves influenced by contextual factors. These include cultural and sociodemographic factors (such as poverty). Moreover, prevention and health promotion measures can influence the levels of childhood obesity. We will now discuss these areas in more detail and describe them in correlation to the results of some identified reviews. An overview of all the influencing factors identified in the review of the literature is included in the annex (Annex Table 1).

3.1 Behaviour

Nutrition
A positive energy balance, which occurs when caloric intake exceeds energy expenditure, is considered the central cause of obesity [16]. Consuming high-energy-dense foods and meals can favour a positive energy balance and promote obesity [17]. It is assumed that when consuming high-energy-dense meals compared to low-energy-dense meals, more energy is taken up by the body before satiety is felt [17]. Concerning nutrient intake, consuming large amounts of simple carbohydrates, proteins and fats are being discussed as factors that could encourage obesity, as opposed to consuming high amounts of dietary fibre, which it is presumed to reduce a person’s likelihood of becoming obese [18–21]. Numerous longitudinal studies have related the regular consumption of sugar-sweetened beverages and fast food to the development of obesity in children and adolescents [22, 23]. Regularly eating fruit and vegetables are considered factors that protect against becoming obese, even though the results of longitudinal studies for children and adolescents are not entirely consistent [24].
Physical activity, sedentary lifestyle and sleep

As it increases energy expenditure and contributes to a more even energy balance, physical activity is considered to be a factor protecting children and adolescents from becoming obese. Several cross-sectional and longitudinal studies have shown an inverse relationship between physical activity and childhood obesity [25, 26]. A sedentary lifestyle and in particular using screen-based media can promote obesity [27]. In addition to the reduced energy requirements of people with a sedentary lifestyle, the effects of advertisements for particular foods (such as sweets) and the consumption of energy-rich foods while using screen-based media are being discussed as potential causes for an increased obesity risk [28]. Studies concerning the 7- to 17-year-old population are, however, not consistent. Too little sleep is a further obesity risk factor currently being discussed, a habit that can cause alterations to the metabolism and at the hormonal level that favour obesity. Longitudinal study results support this hypothesis [29].

3.2 Environments

Living environments

The living environments of children and adolescents play an important role in the development of obesity. We use the term living environment here in the sense of a definable social system to describe the framework conditions in which people live, learn, work and consume [30]. Relevant living environments for school-age girls and boys are the family and home, school and their immediate neighbourhoods (such as the municipality in which they live). Parent weight and health behaviour are principal influencing factors of the family. A meta-analysis indicates that children whose parents are obese have a significantly higher obesity risk [31]. This relationship was stronger for older than for younger children, as well as when both parents were obese. Parent weight has a strong genetic and epigenetic component, which means there are overlaps with biological factors. A number of correlation studies provide insights into how parental health behaviour, such as dietary habits and levels of physical activity, play out in children [32]. Moreover, a review relying principally on cross-sectional studies indicated that shared family meals are associated with a lower obesity risk [33]. For the school environment, a negative influence of unhealthy food options on the weight of adolescents is being discussed; however, only very few studies to date have confirmed such a correlation [34]. For the living environment municipality, the availability of spaces that encourage physical activity [35], security of residential areas [36] and shopping and food options that promote a healthy diet [35] are considered to be factors that protect against obesity. However, the results in the identified reviews, which are mostly based on cross-sectional studies, are inconsistent.

Economic factors

Economic factors that are being discussed as influencing obesity in school-age children and adolescents include the cost of participating in physical activities as well as the price of food and meals. The few available studies show that accessible prices for exercise opportunities can help increase levels of physical activity, as well as that increases to the price of fruit and vegetables are associated with gaining weight [37, 38]. In addition, cross-sectional and longi-
Influencing factors of obesity in school-age children and adolescents

3.4 Pre- and postnatal

Pregnancy
Maternal obesity in the early stages of pregnancy increases the likelihood of their children being obese during childhood and adolescence. Numerous prospective studies provide consistent results for this hypothesis [50, 51]. In addition, several longitudinal show that high maternal weight gain during pregnancy and (gestational) diabetes are risk factors for the development of obesity during childhood and adolescence [51, 52]. The same holds true for mothers who smoke during pregnancy [53, 54].

Early childhood
The results of systematic reviews that consider a high birth weight and rapid weight gain after birth are largely consistent. The results show that these factors can promote obesity at child and adolescent age [55, 56]. Breastfeeding, to the contrary, appears to be a protective factor. As numerous longitudinal studies have shown, how long and how (e.g. exclusive breastfeeding or breastfeeding and complementary feeding) a baby is breastfed potentially influence obesity risks [57, 58].

3.5 Psychosocial factors

Children and adolescents
Certain psychosocial factors are being discussed as potentially relevant for child and adolescent obesity. Various long-term studies indicate depression could promote obesity among girls and boys [59]. It is assumed this association is bi-directional, i.e. obesity would then also be a risk...
factor for depression. Factors that could encourage obesity in the context of a manifest depression and that are currently being discussed include changes to appetite and dietary habits, such as developing a preference for carbohydrate-rich foods, as well as more sedentary habits and sleeping disorders [60]. A number of cross-sectional studies have highlighted a connection between stressful (traumatic) life events, such as suffering violence, and a greater risk of becoming obese [61, 62]. High levels of stress, eating disorders (such as binge eating) and suffering bullying are further influencing factors that encourage obesity and have been described in the literature [60–63]. Longitudinal studies have also shown a weak connection between low self-esteem and the risk of becoming overweight or obese [59]. Overall, the evidence for the stated psychosocial influencing factors has to be rated insufficient and there is a lack of models to explain relationships and effect mechanisms.

3.6 Context

Longitudinal studies indicate that in high income countries such as Germany children and adolescents of low socioeconomic status are more often overweight or obese than their peers from high status groups [69]. In particular, a low parental educational level is considered a risk factor for children and adolescents with regard to the development of obesity, and this factor plays out more heavily in younger than older children. [70]. It is assumed that a low parental educational level is often associated with little health knowledge and only insufficient health literacy, making a health-promoting lifestyle (for example a balanced diet) less probable and therefore supporting the development of obesity in children [70]. Longitudinal studies underline that a low household income can be a risk factor for the development of obesity in children and adolescents, as limited financial resources make it more difficult to access leisure-time activities that involve physical activity and to pay for a healthy diet [71].

Parents and the peer group

Parents facing high levels of stress and mothers suffering from depression can increase a child’s obesity risk [64, 65]. How parents perceive a child’s weight can also be a relevant factor in whether a child becomes obese or not. It is assumed that parents who are conscious that their children are overweight will take action to prevent them from becoming obese [66]. In addition, low levels of parental health literacy could encourage childhood obesity [67]. Moreover, for adolescents, the influence of their peer group can lead to similar weight developments and obesity related behaviours [68]. To date, these influencing factors have only been insufficiently studied.
4. Discussion

This article aims to provide an up-to-date overview of the factors influencing obesity in school-age girls and boys and which are the basis for the indicators of a population-wide monitoring system. As the results of the literature review emphasise, the causes of obesity in school-age girls and boys are diverse and not limited to factors of individual behaviour. Comparisons with the established explanatory models for obesity at child and adolescent age also highlight this [74, 75]. Between the identified factors, it is presumed that links and diverse interactions at numerous levels exist [76]. In addition, the different areas play out differently in the development of obesity regarding their direct or indirect influence (Figure 3). Based on this literature review, it is not possible to quantify the effects of particular factors, as other studies have attempted to do [77–79]. However, the diversity of the influencing factors that were identified highlights that tackling obesity in childhood and adolescence calls for measures in more than just one area. Rather, the strategy should aim to develop health promoting framework conditions in living environments, as this would encourage positive health behaviour [80]. However, this depends on equally addressing the political and economic framework conditions. Monitoring thereby plays a key role: it ensures that developments over time can be tracked and needs to take action can be recognised at an early stage, thereby providing important insights for the planning, implementation and evaluation of prevention measures and strategies [81].

Systematic literature reviews have their limitations. We have accounted for publications with the outcome obesity, but also with a number of alternative outcomes, such as changes of other anthropometric measures (such as body mass index) or behaviours relevant to obesity (such as physical activity). Restricting ourselves to systematic reviews and a search string that looks at titles and the abstract of publications are further limitations. There were also certain limitations with regard to the age groups. The age groups described in the literature often did not fit precisely the 7- to 17-year-old group and only considered a subgroup or also included younger and/or older people. To simplify matters, the terms child and adolescent were therefore used in the results section. It is also important to mention that substantial discrepancies existed in the number of studies found for each factor. The majority of the identified publications dealt with behaviour-related and biological influencing factors. For the areas environment, context, psychosocial factors, as well as pre- and postnatal factors, the search provided fewer systematic reviews. The differing number of identified reviews for specific influence fields possibly also influenced the evaluation of evidence. The synopsis of influencing factors included all factors associated with obesity. These include findings from cross-sectional studies, which do not allow a clean separation of cause and effect and are therefore less robust. This means that in some cases it remains unclear whether the observed relationships are causal, as well as which side of this causality is the effect and how the mechanisms underlying these effects are structured. In addition, the influencing factors which have been considered as only insufficiently researched should nonetheless be considered in the population-wide monitoring. Mostly these are from the areas environment and psychosocial factors, and were included to account for a broad spectrum of influencing factors. To prevent
Influencing factors of obesity in school-age children and adolescents

distortions in the compilation of influencing factors and the evaluation of supporting evidence, the results of the literature review were consolidated during a workshop with external experts.

Conclusion

The results of our systematic review of the literature highlight the complex structure of influencing factors that underlie obesity in school-age girls and boys. Compared to an earlier review on factors that influence the obesity of 0- to 6-year-old children, new influencing factors were identified for the 7- to 17-year-old group. These include aspects from the school environment and factors that gain in importance at secondary school age, such as the influence of the peer group or having suffered bullying.

The literature review also showed that over the last years the causes of obesity among children and adolescents have been amply researched. Further research is nonetheless required. For environmental and psychosocial influencing factors, for example, only few studies are so far available. More findings are required that would allow us to assess the relevance of particular influencing factors for the development of obesity, explain the underlying effect mechanisms and provide effective settings-based prevention measures. Furthermore, future concepts of obesity prevention will need to be based within a broader context. This could include considering the development of indicators to account for the interactions between obesity prevention and environmental and climate aspects [82].

The next step of the AdiMon project will involve reaching a consensus between experts on robust indicators for specific influencing factors, and acquiring the corresponding data sources. Until October 2020, the new indicators for school-age children and adolescents will be integrated into the existing system of indicators and published on the AdiMon website. In the medium to long term, AdiMon will be updated regularly and thereby allow us to map the changes of the diverse influencing factors. AdiMon will thereby provide starting points for new and adequate prevention strategies that will target the individual-, setting- and population-level.

Corresponding author
Franziska Lehmann
Robert Koch Institute
Department of Epidemiology and Health Monitoring
General-Pape-Str. 62–66
12101 Berlin, Germany
E-mail: LehmannF@rki.de

Please cite this publication as
Lehmann F, Varnaccia G, Zeiher J, Lange C, Jordan S (2020)
Influencing factors of obesity in school-age children and adolescents –
A systematic review of the literature in the context of obesity monitoring.
Journal of Health Monitoring 5(S2):2–23.
DOI 10.25646/6729

The German version of the article is available at:
www.rki.de/journalhealthmonitoring

Funding
AdiMon receives funding from the Federal Ministry of Health (funding code: ZMVII-2518KIG700).

Conflicts of interest
The authors declared no conflicts of interest.
Influencing factors of obesity in school-age children and adolescents

References

1. Schienkiewitz A, Brettschneider AK, Damerow S et al. (2018) Overweight and obesity among children and adolescents in Germany. Results of the cross-sectional KiGGS Wave 2 study and trends. Journal of Health Monitoring 3(1):15-22. https://edoc.rki.de/handle/176904/5627.2 (As at 02.02.2020)

2. Simmonds M, Llewellyn A, Owen C et al. (2016) Predicting adult obesity from childhood obesity: a systematic review and meta-analysis. Obes Rev 17(2):95-107

3. Friedemann C, Heneghan C, Mahtani K et al. (2012) Cardiovascular disease risk in healthy children and its association with body mass index: systematic review and meta-analysis. BMJ 345:e4759

4. Park MH, Falconer C, Viner RM et al. (2012) The impact of childhood obesity on morbidity and mortality in adulthood: a systematic review. Obes Rev 13(11):985-1000

5. Butland B, Jebb S, Kopelman P et al. (2007) Foresight Tackling obesities: future choices – project report. Government Office for Science, United Kingdom

6. Birch LL, Ventura AK (2009) Preventing childhood obesity: what works? Int J Obes (Lond) 33:574-581

7. World Health Organization (2016) Report of the commission on ending childhood obesity. WHO, Geneva

8. Varnaccia G, Zeiher J, Lange C et al. (2017) Factors influencing childhood obesity – the establishment of a population-wide monitoring system in Germany. Journal of Health Monitoring 2(2):85-97. https://edoc.rki.de/handle/176904/2638 (As at 02.04.2020)

9. Zeiher J, Varnaccia G, Jordan S et al. (2016) Was sind die Einflussfaktoren kindlicher Adipositas? Eine Literaturübersicht im Rahmen des Projekts “Bevölkerungsweites Monitoring adipositas-relevanter Einflussfaktoren im Kindesalter”. Bundesgesundheitsbl 59(11):1465-1475

10. Plachta-Danielzik S, Landsberg B, Seiberl J et al. (2012) Längsschnittdaten der Kieler Adipositas-Präventionsstudie (KOPS). Bundesgesundheitsbl 55(6-7):885-891

11. von Kries R, Beyerlein A, Müller MJ et al. (2012) Different age-specific incidence and remission rates in pre-school and primary school suggest need for targeted obesity prevention in childhood. Int J Obes (Lond) 36(4):505-510

12. Leibniz-Institut für Bildungsforschung und Bildungsinformation, Deutsches Jugendinstitut, Institut für Schulentwicklungsfor...rchung et al. (2019) Ganztagsschule 2017/2018. Deskriptive Befunde einer bundesweiten Befragung. Studie zur Entwicklung von Ganztagsschulen. Frankfurt am Main, Dortmund, Gießen, München. P. 154–158

13. Robert Koch-Institut (Ed) (2009) Lebensphasenspezifische Gesundheit von Kindern und Jugendlichen in Deutschland. Ergebnisse des Nationalen Kinder- und Jugendgesundheitssurveys (KiGGS). Beiträge zur Gesundheitsberichterstattung des Bundes. RKI, Berlin

14. Harring M, Böhm-Kasper O, Rohlf C et al. (2010) Peers als Bildungs- und Sozialisationsinstanzen – eine Einführung in die Thematik. In: Harring M, Böhm-Kasper O, Rohlfs C et al. (Eds) Freundschaften, Cliquen und Jugendkulturen. VS Verlag für Sozialwissenschaften, Wiesbaden, P. 9–19

15. Pinquart M, Silbereisen RK (2002) Gesundheitsverhalten im Kindes- und Jugendalter. Bundesgesundheitsbl 45(11):873–878

16. Bleich SN, Ku R, Wang YC (2011) Relative contribution of energy intake and energy expenditure to childhood obesity: a review of the literature and directions for future research. Int J Obes (Lond) 35(1):1–15

17. Perez-Escamilla R, Obbagy JE, Altman JM et al. (2012) Dietary energy density and body weight in adults and children: a systematic review. J Acad Nutr Diet 112(5):671–684

18. Harland JI, Garton LE (2008) Whole-grain intake as a marker of healthy body weight and adiposity. Public Health Nutr 11(6):554–563

19. Morenga LT, Mallard S, Mann J (2013) Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. BMJ 345:e7492

20. Pearce J, Langley-Evans SC (2013) The types of food introduced during complementary feeding and risk of childhood obesity: a systematic review. Int J Obes (Lond) 37(4):477–485

21. Naude CE, Visser ME, Nguyen K et al. (2018) Effects of total fat intake on bodyweight in children. Cochrane Database Syst Rev (7):CD012960

22. Rosenheck R (2008) Fast food consumption and increased caloric intake: a systematic review of a trajectory towards weight gain and obesity risk. Obes Rev 9(6):535–47
Influencing factors of obesity in school-age children and adolescents

23. Bucher Della Torre S, Keller A, Laure Depeyre J et al. (2016) Sugarsweetened beverages and obesity risk in children and adolescents: a systematic analysis on how methodological quality may influence conclusions. J Acad Nutr Diet 116(4):638–659

24. Ledoux T, Hingle M, Baranowski T (2011) Relationship of fruit and vegetable intake with adiposity: a systematic review. Obes Rev 12(5):e143-e150

25. Jimenez-Pavon D, Kelly J, Reilly JJ (2010) Associations between objectively measured habitual physical activity and adiposity in children and adolescents: systematic review. Int J Pediatr Obes 5(1):3–18

26. Lee JE, Pope Z, Gao Z (2018) The role of youth sports in promoting children’s physical activity and preventing pediatric obesity: a systematic review. Ann Behav Med 44(1):62–76

27. Biddle SJH, Bengoechea EG, Wiesner G (2017) Sedentary behaviour and adiposity in youth: a systematic review of reviews and analysis of causality. Int J Behav Nutr Phys Act 14(43)

28. Osei-Assibey G, Dick S, Macdiarmid J et al. (2012) The influence of the food environment on overweight and obesity in young children: a systematic review. BMJ Open 2:e000153

29. Miller MA, Kruisbrink M, Wallace J et al. (2018) Sleep duration and incidence of obesity in infants, children, and adolescents: a systematic review and meta-analysis of prospective studies. Sleep 41(4):1–19

30. Rosenbrock R, Hartung S (2015) Settingansatz/Lebenswelt. E-Book: Leitbegriffe der Prävention und Gesundheitsförderung: Glossar zu Konzepten, Strategien und Methoden BZgA, Köln

31. Wang Y, Min J, Khuri J et al. (2017) A systematic examination of the association between parental and child obesity across countries. Adv Nutr 8(3):436–448

32. Cislak A, Safron M, Pratt M et al. (2012) Family-related predictors of body weight and weight-related behaviours among children and adolescents: a systematic umbrella review. Child Care Health Dev 38(3):321–331

33. Valdes J, Rodriguez-Artalejo F, Aguilar L et al. (2013) Frequency of family meals and childhood overweight: a systematic review. Pediatr Obes 8(1):e1–e13

34. Silden KE (2018) Impact of competitive foods in public schools on child nutrition: effects on adolescent obesity in the United States an integrative systematic literature review. Glob Health Action 11(1):1477492

35. Casey R, Oppert JM, Weber C et al. (2014) Determinants of childhood obesity: What can we learn from Built environment studies? Food Qual Prefer 31(1):164–172

36. An R, Yang Y, Hoschke A et al. (2017) Influence of neighbourhood safety on childhood obesity: a systematic review and meta-analysis of longitudinal studies. Obes Rev 18(11):1289–1309

37. Safron M, Cislak A, Gaspar T et al. (2011) Micro-environmental characteristics related to body weight, diet, and physical activity of children and adolescents: a systematic umbrella review. Int J Environ Health Res 21(5):317–330

38. Leal C, Chaix B (2011) The influence of geographic life environments on cardiometabolic risk factors: a systematic review, a methodological assessment and a research agenda. Obes Rev 12(3):217–230

39. Kelly B, King L, Chapman K et al. (2015) A Hierarchy of Unhealthy Food Promotion Effects: Identifying Methodological Approaches and Knowledge Gaps. Am J Public Health 105(4):E86–E95

40. Albuquerque D, Nobrega C, Manco L et al. (2017) The contribution of genetics and environment to obesity. Br Med Bull 123(1):159–173

41. Silventoinen K, Rohholm B, Kaprio J et al. (2010) The genetic and environmental influences on childhood obesity: a systematic review of twin and adoption studies. Int J Obes (Lond) 34(1):29–40

42. Arslan N, Erdur B, Aydin A (2010) Hormones and cytokines in childhood obesity. Indian Pediatr 47(10):829–839

43. Indiani C, Rizzardi KF, Castelo PM et al. (2018) Childhood obesity and firmicutes/bacteroidetes ratio in the gut microbiota: a systematic review. Child Obes 14(8):501–509

44. Leinaar E, Alamian A, Wang L (2016) A systematic review of the relationship between asthma, overweight, and the effects of physical activity in youth. Ann Epidemiol 26(7):504–510

45. Shang QL, Wang HP, Song YJ et al. (2014) Serological data analyses show that adenovirus 36 infection is associated with obesity: a meta-analysis involving 5739 subjects. Obesity 22(3):895–900

46. Miller SA, Wu RKS, Oremus M (2018) The association between antibiotic use in infancy and childhood overweight or obesity: a systematic review and meta-analysis. Pediatrics 141(3):e20172534

47. Cattuzzo MT, Henrique RD, Re AHN et al. (2016) Motor competence and health related physical fitness in youth: a systematic review. J Sci Med Sport 19(2):123–129
Influencing factors of obesity in school-age children and adolescents

48. Mintjens S, Menting MD, Daams JG et al. (2018) Cardiorespiratory fitness in childhood and adolescence affects future cardiovascular risk factors: a systematic review of longitudinal studies. Sports Medicine 48(11):2577–2605

49. Smith JI, Eather N, Morgan PJ et al. (2014) The health benefits of muscular fitness for children and adolescents: a systematic review and meta-analysis. Sports Medicine 44(9):1209–1223

50. Yu ZB, Han SP, Zhu JG et al. (2013) Pre-pregnancy body mass index in relation to infant birth weight and offspring overweight/obesity: a systematic review and meta-analysis. PLoS ONE 8(4)

51. Baidal JAW, Locks LM, Cheng ER et al. (2016) Risk factors for childhood obesity in the first 1,000 days: a systematic review. Am J Prev Med 50(6):761–779

52. Tie HT, Xia YY, Zeng YS et al. (2014) Risk of childhood overweight or obesity associated with excessive weight gain during pregnancy: a meta-analysis. Arch Gynecol Obstet 289(2):247–257

53. Rayfield S, Pluggé E (2017) Systematic review and meta-analysis of the association between maternal smoking in pregnancy and childhood overweight and obesity. J Epidemiol Community Health 71(2):162–173

54. Qureshi R, Jadotte Y, Zha P et al. (2018) The association between prenatal exposure to environmental tobacco smoke and childhood obesity: a systematic review. JBI Database System Rev Implement Rep 16(8):1643–1662

55. Schellong K, Schulz S, Harder T et al. (2012) Birth weight and long-term overweight risk: systematic review and a meta-analysis including 643,902 persons from 66 studies and 26 countries globally. PLoS ONE 7(10):e47776

56. Zheng M, Lamb KE, Grimes C et al. (2018) Rapid weight gain during infancy and subsequent adiposity: a systematic review and meta-analysis of evidence. Obes Rev 19(5):321–332

57. Yan J, Liu L, Zhu Y et al. (2014) The association between breastfeeding and childhood obesity: a meta-analysis. BMC Public Health 14:1267

58. Newsome K, Rashid T, Vonville HM et al. (2016) Mapping of reviews on breastfeeding and obesity risk in children. Curr Nutr Rep 5(4):255–277

59. Incledon E, Wake M, Hay M (2011) Psychological predictors of adiposity: systematic review of longitudinal studies. Int J Pediatr Obes 6:sup3, e1-11

60. Mannan M, Mamun A, Doi S et al. (2016) Prospective associations between depression and obesity for adolescent males and females - a systematic review and meta-analysis of longitudinal studies. PLoS ONE 11(6):e0157240

61. Danese A, Tan M (2014) Childhood maltreatment and obesity: systematic review and meta-analysis. Mol Psychiatry 19(5):544–554

62. Midei AJ, Matthews KA (2011) Interpersonal violence in childhood as a risk factor for obesity: a systematic review of the literature and proposed pathways. Obes Rev 12(501):e159–e172

63. Russell-Mayhew S, McVey G, Bardick A et al. (2012) Mental health, wellness, and childhood overweight/obesity. Int J Obes (Lond) 2012:281801

64. O’Connor SG, Maher JP, Belcher BR et al. (2017) Associations of maternal stress with children’s weight-related behaviours: a systematic literature review. Obes Rev 18(5):514–525

65. Lampard AM, Franckle RL, Davison KK (2014) Maternal depression and childhood obesity: a systematic review. Prev Med 59:60–67

66. Tompkins CL, Seablom M, Brock DW (2015) Parental perception of child’s body weight: a systematic review. J Child Fam Stud 24(5):1384–1391

67. Marks R (2015) Childhood obesity and parental health literacy. Advances in Obesity, Weight Management & Control 3(3):00055

68. Cunningham SA, Vaquera E, Maturo CC et al. (2012) Is there evidence that friends influence body weight? A systematic review of empirical research. Soc Sci Med 75(7):1175–1183

69. Wu SQ, Ding YY, Wu FQ et al. (2015) Socio-economic position as an intervention against overweight and obesity in children: a systematic review and meta-analysis. Sci Rep 5:11354

70. Kim TJ, Roesler NM, von dem Knesebeck O (2017) Causation or selection - examining the relation between education and overweight/obesity in prospective observational studies: a meta-analysis. Obes Rev 18(6):660–672

71. Barriuso L, Migueleiz E, Albaladejo R et al. (2015) Socioeconomic position and childhood-adolescent weight status in rich countries: a systematic review. BMC Pediatr 15:129

72. Labree LJW, van de Mheen H, Rutten FFH et al. (2011) Differences in overweight and obesity among children from migrant and native origin: a systematic review of the European literature. Obes Rev 12(501):e535–e547
Influencing factors of obesity in school-age children and adolescents

73. Koschollek C, Bartig S, Rommel A et al. (2019) The health of children and adolescents with a migration background in Germany – Results of the cross-sectional KiGGS Wave 2 study. 4(3):7–28. https://edoc.rki.de/handle/176904/6109 (As at 02.04.2020)

74. Lytle LA (2009) Examining the etiology of childhood obesity: the IDEA study. Am J Community Psychol 44(3–4):338–349

75. Davison KK, Birch LL (2001) Childhood overweight: a contextual model and recommendations for future research. Obes Rev 2(3):159–171

76. Plachta-Danielzik S, Müller MJ (2018) Determinanten des Übergewichts bei Kindern und Jugendlichen. In: Dadaczynski K, Quilling E, Walter U (Eds) Übergewichtsprävention im Kindes und Jugendalter. Hogrefe, Bern, P. 43–52

77. Plachta-Danielzik S, Kehden B, Landsberg B et al. (2012) Attributable Risks for Childhood Overweight: Evidence for Limited Effectiveness of Prevention. Pediatrics 130(4):e865–e871

78. Kovács E, Hunsberger M, Reisch L et al. (2015) Adherence to combined lifestyle factors and their contribution to obesity in the IDEFICS study. Obes Rev 16(S2):138–150

79. Kleiser C, Schaffrath Rosario A, Mensink GBM et al. (2009) Potential determinants of obesity among children and adolescents in Germany: results from the cross-sectional KiGGS study. BMC Public Health 9(1):46

80. Lange D, Plachta-Danielzik S, Landsberg B et al. (2010) Soziale Ungleichheit, Migrationshintergrund, Lebenswelten und Übergewicht bei Kindern und Jugendlichen. Ergebnisse der Kieler Adipositas-Präventionsstudie (KOPS). Bundesgesundheitsbl 53(7):707–715

81. Walter U, Dadaczynski K, Quilling E (2018) Herausforderungen und Überlegungen für zukünftige Orientierungen – ein Fazit zur Prävention von Übergewicht bei Kindern und Jugendlichen. In: Dadaczynski K, Quilling E, Walter U (Eds) Übergewichtsprävention im Kindes und Jugendalter. Hogrefe, Bern, P. 375–387

82. Swinburn BA, Kraaik, Allender S et al. (2019) The global syndemic of obesity, undernutrition, and climate change: the Lancet Commission report. The Lancet 393(10173):791–846
# Influencing factors of obesity in school-age children and adolescents

## Annex Table 1
Influencing factors of obesity in school-age girls and boys (updated: May 2019)

Source: Own table

| Influencing factor | Relationship | Literature* |
|--------------------|--------------|-------------|
| **Behaviour**      |              |             |
| **Physical activity** |              |             |
| Physical activity  | Regular physical activity can help prevent obesity. | [1, 2] |
| Sports activity    | Regular sports activity can help prevent obesity.  | [3, 4] |
| **Sedentary behaviour** |              |             |
| Sitting time       | Regularly spending time sitting can favour obesity. | [5, 6] |
| Screen time        | Regularly spending time in front of a screen can favour obesity. | [5, 7] |
| **Diet**           |              |             |
| Energy intake      | Taking up a high amount of energy can favour obesity. | [8] |
| Carbohydrates      | Taking up large amounts of carbohydrates and/or consuming particular types of carbohydrates such as fructose, can favour obesity. | [9–11] |
| Proteins           | Taking up large amounts of proteins in early childhood can favour obesity. | [12] |
| Fat                | Taking up large amounts of fat can favour obesity. | [13] |
| Fibres             | Taking up large amounts of fibres can help prevent obesity. | [14] |
| Vitamins and minerals | Vitamin and mineral uptake can be a relevant factor for obesity. | [15–17] |
| Energy density     | High-energy-density foods can favour obesity. | [18] |
| Sugar-sweetened beverages | Regularly consuming sugar-sweetened beverages can favour obesity. | [19] |
| Fruit and vegetables | Regularly eating fruit and vegetables can prevent obesity. | [20] |
| Fast food          | Regularly eating fast food can favour obesity. | [21, 22] |
| Milk and milk products | Regularly consuming milk and milk products can help prevent obesity. | [23] |
| Dietary patterns   | Particular dietary patterns (such as eating mainly highly processed foods) can be a relevant factor for obesity. | [24] |
| Meal frequency     | A high frequency of meals can help prevent obesity. | [25] |
| Breakfast          | Regularly eating breakfast can help prevent obesity. | [26] |
| **Sleep**          |              |             |
| Sleep duration     | A short sleep duration can favour obesity. | [27–29] |
| **Environment**    |              |             |
| Parental obesity   | Parental obesity can favour obesity in their children. | [30] |
| Parental health behaviour | A healthy parental lifestyle can help prevent obesity in their children. | [31] |
| Sibling health behaviour | A healthy lifestyle of siblings can help prevent obesity. | [31] |
| Home food environment | A balanced offer of food and meals at home can help prevent obesity. | [31] |
| Shared family meals | Shared family meals can help prevent obesity. | [32] |
| School food environment | A balanced offer of food and meals at school can help prevent obesity. | [33] |
| Opportunities for physical activity at school | Spaces and opportunities for physical activity at school can help prevent obesity. | [34] |
| Spaces for physical activity in the neighbourhood | Spaces for physical activity in the neighbourhood (such as parks, sports facilities, playground) can help prevent obesity. | [35] |
| Sports offers      | Sports offers (for example sports clubs) can help prevent obesity. | [34] |
| Activity-promoting infrastructure | Activity-promoting infrastructure (for example walkability) can help prevent obesity. | [35] |

*The references represent a selected number of publications (in the review of the literature 280 relevant publications were identified). Continued on next page
### Influencing factors of obesity in school-age children and adolescents

**Environment**

- **Living environment**
  - Security in the neighbourhood: A secure environment in the neighbourhood or one that is perceived as being secure can help prevent obesity. [36]
  - Shops and food options: Shops and food options (for example fast food restaurants) can be a relevant factor for obesity. [35]
  - Degree of urbanisation: Growing up in rural communities can favour obesity. [37]
  - Regional deprivation: Growing up in a deprived area can favour obesity. [38]

- **Economic factors**
  - Costs related to physical activities: Costs related to physical activities can be a relevant factor for obesity. [34]
  - Prices of food and meals: The price of food and meals can be a relevant factor for obesity. [39]
  - Advertisements: Advertisements for high-energy-density foods can favour obesity. [40]

- **Other factors**
  - Pollutants: Certain pollutants (such as bisphenol A) can favour obesity. [41]
  - Portion sizes: Large portion sizes can favour obesity. [42]

**Biology**

- **Genetic factors**
  - Genes and gene combinations: Certain genes and combinations of genes can be relevant factors for obesity. [43]

- **Hormonal factors**
  - Hormones: Certain hormones (such as leptin) can be a relevant factor for obesity. [44]

- **Micro-biological factors**
  - Intestinal flora: Intestinal flora composition can be a relevant factor for obesity. [45]

- **Physical fitness**
  - Motor fitness: Strong motor fitness can help prevent obesity. [46]
  - Cardio-respiratory fitness: Strong cardio-respiratory fitness can help prevent obesity. [47]
  - Muscular fitness: Strong muscular fitness can help prevent obesity. [48]

- **Other factors**
  - Puberty: Precocious puberty can favour obesity. [49]
  - Diseases and viruses: Certain diseases (such as autism and asthma) and viruses (such as adenoviruses) can favour obesity. [50–52]
  - Medication: Certain medications (such as antibiotics) can favour obesity. [53, 54]

**Pre and postnatal**

- **Pregnancy**
  - Maternal body mass index: A high maternal body mass index in the early stages of pregnancy can favour childhood obesity. [55, 56]
  - Maternal weight gain: A high maternal weight gain during pregnancy can favour childhood obesity. [55, 57]
  - Maternal diabetes: Maternal (gestational) diabetes during pregnancy can favour childhood obesity. [55, 58]
  - Maternal smoking: Maternal smoking during pregnancy can favour childhood obesity. [59, 60]
  - Maternal passive smoking: Maternal passive smoking during pregnancy can favour childhood obesity. [59, 61]

- **Early childhood**
  - Weight at birth: A high birth weight can favour obesity. [55, 62]
  - Caesarean section: Caesarean section can favour obesity. [63]
  - Breastfeeding: Breastfeeding can help prevent obesity. [64, 65]
  - Duration of breastfeeding: Breastfeeding over an extended period can help prevent obesity. [64, 65]

---

Annex Table 1: Continued

Influencing factors of obesity in school-age girls and boys (updated: May 2019)

Source: Own table
# Influencing factors of obesity in school-age children and adolescents

## Pre and postnatal

| Influencing factor                  | Relationship                                                                 | Literature |
|-------------------------------------|------------------------------------------------------------------------------|------------|
| Early childhood                     |                                                                              |            |
| Form of breastfeeding               | The form of breastfeeding (for example any form of breastfeeding, exclusive breastfeeding, bottle feeding) can be a relevant factor for obesity. | [55]       |
| Complementary feeding               | Early complementary feeding (before the fourth month) can favour obesity.      | [66]       |
| Rapid weight gain                   | A rapid weight gain during the first months of life can favour obesity.        | [67]       |
| Tonsillectomy                       | A tonsillectomy can favour obesity.                                          | [68]       |
| Child-care attendance               | Attending child-care at an early age (0- to 2-years) can favour obesity.      | [55]       |

## Psychosocial factors

| Influencing factor                  | Relationship                                                                 | Literature |
|-------------------------------------|------------------------------------------------------------------------------|------------|
| Children and adolescents            |                                                                              |            |
| Personality traits                  | Certain personality traits (such as impulsivity, self-regulation) can be relevant factors for obesity. | [69]       |
| Self-esteem                         | Having low self-esteem can favour obesity.                                   | [70]       |
| Family climate                      | An unfavourable family climate can favour obesity.                          | [71]       |
| Parent-child relationship            | A weak parent-child relationship can favour obesity.                         | [72]       |
| Social support                      | Social support can help prevent obesity.                                     | [73]       |
| Stress                              | High levels of stress can favour obesity.                                    | [74]       |
| Stressful life events               | Stressful life events (such as maltreatment) can favour obesity.             | [75, 76]   |
| Bullying                            | Bullying can favour obesity.                                                 | [76]       |
| Eating disorders                    | Eating disorders (such as restrictive eating and binge eating) can favour obesity. | [77]       |
| ADHD                                | Attention Deficit and Hyperactivity Disorder (ADHD) can favour obesity.      | [78]       |
| Depression                          | Depression can favour obesity.                                               | [79]       |
| Peer group                          |                                                                              | [80, 81]   |

## Parents

| Influencing factor                  | Relationship                                                                 | Literature |
|-------------------------------------|------------------------------------------------------------------------------|------------|
| Stress levels                       | High levels of parental stress can favour obesity in their children.         | [82]       |
| Depression                          | Maternal depression can favour childhood obesity.                            | [83]       |
| Parental perception of child’s body weight | Parental misperception of their child’s body weight can favour childhood obesity. | [84, 85]   |
| Health literacy                     | Insufficient parental health literacy can favour obesity in their children.  | [86]       |
| Parenting style                     | An authoritative parenting style can help prevent obesity.                   | [87, 88]   |
| Feeding style                       | How and when a child is given food can be relevant for obesity.              | [87]       |

## Context

| Influencing factor                  | Relationship                                                                 | Literature |
|-------------------------------------|------------------------------------------------------------------------------|------------|
| Social status                       | A low social status can favour obesity.                                      | [89, 90]   |
| Child’s educational level           | A low child’s educational level can favour obesity.                          | [91]       |
| Parental educational status         | A low parental educational status can favour obesity in their children.      | [91]       |
| Parent employment                   | The numbers of hours parents work can be relevant for obesity in their children. | [89]       |
| Poverty                             | Financial poverty can favour obesity.                                        | [92]       |
| Migration background                | A migration background can be relevant for obesity.                          | [93]       |
| Single parent families              | Growing up in a single-parent household can favour obesity.                  | [93]       |
| Siblings                            | Growing up as an only child can favour obesity.                              | [94]       |
| Order of birth                      | The order of birth can be relevant for obesity.                              | [94]       |
Influencing factors of obesity in school-age children and adolescents

References Annex

1. Elmesmari R, Martin A, Reilly JJ et al. (2018) Comparison of accelerometer measured levels of physical activity and sedentary time between obese and non-obese children and adolescents: a systematic review. BMC Pediatr 18(106)

2. Jimenez-Pavon D, Kelly J, Reilly JJ (2010) Associations between objectively measured habitual physical activity and adiposity in children and adolescents: systematic review. International Int J Pediatr Obes 5(1):3–18

3. Lee JE, Pope Z, Gao Z (2018) The role of youth sports in promoting children’s physical activity and preventing pediatric obesity: a systematic review. Behav Med 44(1):62–76

4. Nelson TF, Stovitz SD, Thomas M et al. (2011) Do youth sports prevent pediatric obesity? A systematic review and commentary. Curr Sports Med Rep 10(6):360–370

5. Biddle SJH, Bengoechea EG, Wiesner G (2017) Sedentary behaviour and adiposity in youth: a systematic review of reviews and analysis of causality. Int J Behav Nutr Phys Act 14(43)

6. De Rezende LFM, Lopes MR, Rey-Lopez JP et al. (2014) Sedentary behavior and health outcomes: an overview of systematic reviews. PLoS ONE 9(8)

7. Zhang G, Wu L, Zhou LL et al. (2016) Television watching and risk of childhood obesity: a meta-analysis. Eur J Public Health 26(1):13–18

8. Bleich SN, Ku R, Wang YC (2011) Relative contribution of energy intake and energy expenditure to childhood obesity: a review of the literature and directions for future research. Int J Obes (Lond) 35(1):1–15

9. Morgan RE (2013) Does consumption of high-fructose corn syrup beverages cause obesity in children? Pediatr Obes 8(4):249–254

10. Morenga LT, Maillard S, Mann J (2013) Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. BMJ 345(7891)

11. Aller E, Abete I, Astrup A et al. (2011) Starches, Sugars and Obesity. Nutrients 3(3):341–369

12. Pearce J, Langley-Evans SC (2013) The types of food introduced during complementary feeding and risk of childhood obesity: a systematic review. Int J Obes (Lond) 37(4):477–485

13. Naude CE, Visser ME, Nguyen KA et al. (2018) Effects of total fat intake on bodyweight in children. Cochrane Database Syst Rev (7):CD012960

14. Harland JL, Garton LE (2008) Whole-grain intake as a marker of healthy body weight and adiposity. Public Health Nutr 11(6):554–563

15. Cheng L (2018) The convergence of two epidemics: vitamin D deficiency in obese school-aged children. J Pediatr Nurs 38:20–26

16. Hosseini B, Saedisomeolia A, Allman-Farinelli M (2017) Association between antioxidant intake/status and obesity: a systematic review of observational studies. Biol Trace Elem Res 175(2):287–297

17. Uusi-Rasi K, Karkkainen MUM, Lamberg-Allardt CJ (2013) Calcium intake in health maintenance – a systematic review. Food Nutr Res 57:21082

18. Perez-Escamilla R, Obbagy JE, Altman JM et al. (2012) Dietary energy density and body weight in adults and children: a systematic review. J Acad Nutr Diet 112(5):671–684

19. Bucher Della Torre S, Keller A, Laure Depeyre J et al. (2016) Sugar-sweetened beverages and obesity risk in children and adolescents: a systematic analysis on how methodological quality may influence conclusions. J Acad Nutr Diet 116(4):638–659

20. Ledoux T, Hingle M, Baranowski T (2011) Relationship of fruit and vegetable intake with adiposity: a systematic review. Obes Rev 12(5):e143–e150

21. Schneider BC, Dumith SC, Orlandi SP et al. (2017) Diet and body fat in adolescence and early adulthood: a systematic review of longitudinal studies. Cien Saude Colet 22(5):1539–1552

22. Rosenheck R (2008) Fast food consumption and increased caloric intake: a systematic review of a trajectory towards weight gain and obesity risk. Obes Rev 9(6):535–547

23. Café ACC, De Oliveira Lopes CA, Novais RLR et al. (2018) Intake of sugar-sweetened beverages, milk and its association with body mass index in adolescence: a systematic review. Rev Paul Pediatr 36(1):91–99

24. Ambrosini GL (2014) Childhood dietary patterns and later obesity: a review of the evidence. Proc Nutr Soc 73(1):137–146

25. Kaisari P, Yannakoulia M, Panagiotakos DB (2013) Eating frequency and overweight and obesity in children and adolescents: a meta-analysis. Pediatrics 131(5):958–967

26. Szajewska H, Ruszczynski M (2010) Systematic review demonstrating that breakfast consumption influences body weight outcomes in children and adolescents in europe. Crit Rev Food Sci Nutr 50(2):113–119
Influencing factors of obesity in school-age children and adolescents

27. Miller MA, Kruisbrink M, Wallace J et al. (2018) Sleep duration and incidence of obesity in infants, children, and adolescents: a systematic review and meta-analysis of prospective studies. Sleep 41(4)

28. Wu YH, Gong QH, Zou ZQ et al. (2017) Short sleep duration and obesity among children: a systematic review and meta-analysis of prospective studies. Obes Res Clin Pract 11(2):140–150

29. Li L, Zhang S, Huang YB et al. (2017) Sleep duration and obesity in children: a systematic review and meta-analysis of prospective cohort studies. J Paediatr Child Health 53(4):378–385

30. Wang Y, Min J, Khuri J et al. (2017) A systematic examination of the association between parental and child obesity across countries. Adv Nutr 8(3):436–448

31. Cislak A, Safron M, Pratt M et al. (2012) Family-related predictors of body weight and weight-related behaviours among children and adolescents: a systematic umbrella review. Child Care Health Dev 38(3):321–331

32. Valdes J, Rodriguez-Artalejo F, Aguilar L et al. (2013) Frequency of family meals and childhood overweight: a systematic review. Pediatr Obes 8(1):e1–e13

33. Sildén KE (2018) Impact of competitive foods in public schools on child nutrition: effects on adolescent obesity in the United States an integrative systematic literature review. Glob Health Action 11(1)

34. Safron M, Cislak A, Gaspar T et al. (2011) Micro-environmental characteristics related to body weight, diet, and physical activity of children and adolescents: a systematic umbrella review. Int J Environ Health Res 21(5):317–330

35. Casey R, Oppert JM, Weber C et al. (2014) Determinants of childhood obesity: What can we learn from built environment studies? Food Qual Prefer 31(1):164–172

36. An R, Yang Y, Hoschke A et al. (2017) Influence of neighbourhood safety on childhood obesity: a systematic review and meta-analysis of longitudinal studies. Obes Rev 18(11):1289–1309

37. Johnson JA, Johnson AM (2015) Urban-rural differences in childhood and adolescent obesity in the United States: a systematic review and meta-analysis. Child Obes 11(3):233–241

38. Lovasi GS, Hutson MA, Guerra M et al. (2009) Built environments and obesity in disadvantaged populations. Epidemiol Rev 31:7–20

39. Leal C, Chaix B (2011) The influence of geographic life environments on cardiometabolic risk factors: a systematic review, a methodological assessment and a research agenda. Obes Rev 12(3):217–230

40. Kelly B, King L, Chapman K et al. (2015) A Hierarchy of Unhealthy Food Promotion Effects: Identifying Methodological Approaches and Knowledge Gaps. Am J Public Health 105(4):E86–E95

41. Vrijheid M, Casas M, Gascon M et al. (2016) Environmental pollutants and child health – a review of recent concerns. Int J Hyg Environ Health 219(4–5):331–342

42. Osei-Assibey G, Dick S, Macdiarmid J et al. (2012) The influence of the food environment on overweight and obesity in young children: a systematic review. BMJ Open 2(6)

43. Albuquerque D, Nobrega C, Manco L et al. (2017) The contribution of genetics and environment to obesity. Br Med Bull 123(1):159–173

44. Arslan N, Erdur B, Aydin A (2010) Hormones and cytokines in childhood obesity. Indian J Pediatr 47(10):829–839

45. Indiani C, Rizzardi KF, Castelo PM et al. (2018) Childhood obesity and firmicutes/bacteroidetes ratio in the gut microbiota: a systematic review. Child Obes 14(8):501–509

46. Cattuzzo MT, Henrique RD, Re AHN et al. (2016) Motor competence and health related physical fitness in youth: a systematic review. J Sci Med Sport 19(2):123–129

47. Mintjens S, Menting MD, Daams JG et al. (2018) Cardiorespiratory fitness in childhood and adolescence affects future cardio-vascular risk factors: a systematic review of longitudinal studies. Sports Med 48(11):2577–2605

48. Smith JJ, Eather N, Morgan PJ et al. (2014) The health benefits of muscular fitness for children and adolescents: a systematic review and meta-analysis. Sports Med 44(9):1209–1223

49. Kaplowitz PB (2008) Link between body fat and the timing of puberty. Pediatrics 121 Suppl 3:S208–217

50. Zheng Z, Zhang L, Li SP et al. (2017) Association among obesity, overweight and autism spectrum disorder: a systematic review and meta-analysis. Sci Rep 7:11697

51. Shang QL, Wang HP, Song YJ et al. (2014) Serological data analyses show that adenovirus 36 infection is associated with obesity: a meta-analysis involving 5739 subjects. Obesity 22(3):895–900
Influencing factors of obesity in school-age children and adolescents

52. Leinaar E, Alamian A, Wang L (2016) A systematic review of the relationship between asthma, overweight, and the effects of physical activity in youth. Ann Epidemiol 26(7):504–510

53. Miller SA, Wu RKS, Oremus M (2018) The association between antibiotic use in infancy and childhood overweight or obesity: a systematic review and meta-analysis. Obes Rev 19(11):1463–1475

54. Shao XQ, Ding XL, Wang B et al. (2017) Antibiotic exposure in early life increases risk of childhood obesity: a systematic review and meta-analysis. Front Endocrinol 8:170

55. Baidal JAW, Locks LM, Cheng ER et al. (2016) Risk factors for childhood obesity in the first 1,000 days: a systematic review. Am J Prev Med 50(6):761–779

56. Yu ZB, Han SP, Zhu JG et al. (2013) Pre-pregnancy body mass index in relation to infant birth weight and offspring overweight/obesity: a systematic review and meta-analysis. PLoS ONE 8(4)

57. Tie HT, Xia YY, Zeng YS et al. (2014) Risk of childhood overweight or obesity associated with excessive weight gain during pregnancy: a meta-analysis. Arch Gynecol Obstet 289(2):247–257

58. Philipps LH, Santhakumaran S, Gale C et al. (2011) The diabetic pregnancy and offspring BMI in childhood: a systematic review and meta-analysis. Diabetologia 54(8):1957–1966

59. Qureshi R, Jodote Y, Zha P et al. (2018) The association between prenatal exposure to environmental tobacco smoke and childhood obesity: a systematic review. JBI Database System Rev Implement Rep 16(8):1643–1662

60. Rayfield S, Pluge E (2017) Systematic review and meta-analysis of the association between maternal smoking in pregnancy and childhood overweight and obesity. J Epidemiol Community Health 71(2):162–173

61. Riedel C, Schonberger K, Yang SM et al. (2014) Parental smoking and childhood obesity: higher effect estimates for maternal smoking in pregnancy compared with paternal smoking – a meta-analysis. Int J Epidemiol 43(5):1593–1606

62. Schellong K, Schulz S, Harder T et al. (2012) Birth weight and long-term overweight risk: systematic review and a meta-analysis including 643,902 persons from 66 studies and 26 countries globally. PLoS ONE 7(10)

63. Kuhle S, Tong OS, Woolcott CG (2013) Association between caesarean section and childhood obesity: a systematic review and meta-analysis. Obes Rev 16(4):295–303

64. Newsome K, Rashid T, Vonville HM et al. (2016) Mapping of reviews on breastfeeding and obesity risk in children. Curr Nutr Rep 5(4):255–277

65. Yan J, Liu L, Zhu Y et al. (2014) The association between breastfeeding and childhood obesity: a meta-analysis. BMC Public Health 14:1267

66. Wang J, Wu Y, Xiong G et al. (2016) Introduction of complementary feeding before 4 months of age increases the risk of childhood overweight or obesity: A meta-analysis of prospective cohort studies. Nutr Res 36(8):759–770

67. Zheng M, Lamb KE, Grimes C et al. (2018) Rapid weight gain during infancy and subsequent adiposity: a systematic review and meta-analysis of evidence. Obes Rev 19(3):321–332

68. Jayakumar A, Fettman N, Armbrecht ES et al. (2011) A systematic review of adenotonsillectomy as a risk factor for childhood obesity. Otolaryngol Head Neck Surg 144(2):154–158

69. Liang J, Matheson BE, Kaye WH et al. (2014) Neurocognitive correlates of obesity and obesity-related behaviors in children and adolescents. Int J Obes (Lond) 38(4):494–506

70. Incledon E, Wake M, Hay M (2011) Psychological predictors of adiposity: systematic review of longitudinal studies. Int J Pediatr Obes 6(2–2):e1–e11

71. Halliday JA, Palma CL, Mellor D et al. (2014) The relationship between family functioning and child and adolescent overweight and obesity: a systematic review. Int J Obes (Lond) 8(4):480–493

72. Biewitt C, Bergmeier H, Macdonald JA et al. (2016) Associations between parent-child relationship quality and obesogenic risk in adolescence: a systematic review of recent literature. Obes Rev 17(7):612–622

73. Sloop N, Goodman E, Koenen KC et al. (2013) Socioeconomic and other social stressors and biomarkers of cardiometabolic risk in youth: a systematic review of less studied risk factors. PLoS ONE 8(5)

74. Conklin AI, Guo SX, Tam AC et al. (2018) Gender, stressful life events and interactions with sleep: a systematic review of determinants of adiposity in young people. BMJ Open 8(7):e019982

75. Danese A, Tan M (2014) Childhood maltreatment and obesity: systematic review and meta-analysis. Mol Psychiatry 19(5):544–554

76. Midei AJ, Matthews KA (2011) Interpersonal violence in childhood as a risk factor for obesity: a systematic review of the literature and proposed pathways. Obes Rev 12(501):e159–e172

77. Russell-Mayhew S, McVey G, Bardick A et al. (2012) Mental health, wellness, and childhood overweight/obesity. J Obes 2012:281801
Influencing factors of obesity in school-age children and adolescents

78. Cortese S, Moreira-Maia CR, St Fleur D et al. (2016) Association between ADHD and obesity: a systematic review and meta-analysis. Am J Psychiatry 173(1):34–43

79. Mannan M, Mamun A, Doi S et al. (2016) Prospective associations between depression and obesity for adolescent males and females – a systematic review and meta-analysis of longitudinal studies. PLoS ONE 11(6)

80. Badaly D (2013) Peer similarity and influence for weight-related outcomes in adolescence: a meta-analytic review. Clin Psychol Rev 33(8):1218–1236

81. Cunningham SA, Vaquera E, Maturo CC et al. (2012) Is there evidence that friends influence body weight? A systematic review of empirical research. Soc Sci Med 75(7):1175–1183

82. O’Connor SG, Maher JP, Belcher BR et al. (2017) Associations of maternal stress with children’s weight-related behaviours: a systematic literature review. Obes Rev 18(5):514–525

83. Lampard AM, Franckle RL, Davison KK (2014) Maternal depression and childhood obesity: a systematic review. Prev Med 59:60–67

84. Tompkins CL, Seablom M, Brock DW (2015) Parental perception of child’s body weight: a systematic review. J Child Fam Stud 24(5):1384–1391

85. Rietmeijer-Mentink M, Paulis WD, van Middelkoop M et al. (2013) Difference between parental perception and actual weight status of children: a systematic review. Matern Child Nutr 9(1):3–22

86. Marks R (2015) Childhood obesity and parental health literacy. AOWMC 3(3):00055

87. Shloim N, Edelson LR, Martin N et al. (2015) Parenting styles, feeding styles, feeding practices, and weight status in 4–12 year-old children: a systematic review of the literature. Front Psychol 6:1849

88. Sokol RL, Qin B, Poti JM (2017) Parenting styles and body mass index: a systematic review of prospective studies among children. Obes Rev 18(3):281–292

89. Wu SQ, Ding YY, Wu FQ et al. (2015) Socio-economic position as an intervention against overweight and obesity in children: a systematic review and meta-analysis. Sci Rep 5:11354

90. Barriuso L, Miqueliz E, Albaladejo R et al. (2015) Socioeconomic position and childhood-adolescent weight status in rich countries: a systematic review, 1990–2013. BMC Pediatr 15:129

91. Kim TJ, Roesler NM, von dem Knesebeck O (2017) Causation or selection – examining the relation between education and overweight/obesity in prospective observational studies: a meta-analysis. Obes Rev 18(6):660–672

92. Kim TJ, von dem Knesebeck O (2018) Income and obesity: what is the direction of the relationship? A systematic review and meta-analysis. BMJ Open 8:e019862

93. Labree L JW van de Mheen H, Rutten FFH et al. (2011) Differences in overweight and obesity among children from migrant and native origin: a systematic review of the European literature. Obes Rev 12(501):e535–e547

94. Park SH, Cormier E (2018) Influence of siblings on child health behaviors and obesity: a systematic review. J Child Fam Stud 27(7):2069–2081
Influencing factors of obesity in school-age children and adolescents

Imprint

Journal of Health Monitoring

Publisher
Robert Koch Institute
Nordufer 20
13353 Berlin, Germany

Editors
Johanna Gutsche, Dr Birte Hintzpeter, Dr Franziska Prütz,
Dr Martina Rabenberg, Dr Alexander Rommel, Dr Livia Ryl,
Dr Anke-Christine Saß, Stefanie Seeling, Martin Thißen,
Dr Thomas Ziese
Robert Koch Institute
Department of Epidemiology and Health Monitoring
Unit: Health Reporting
General-Pape-Str. 62–66
12101 Berlin, Germany
Phone: +49 (o)30-18 754-3400
E-mail: healthmonitoring@rki.de
www.rki.de/journalhealthmonitoring-en

Typesetting
Gisela Dugnus, Kerstin Möllerke, Alexander Krönke

Translation
Simon Phillips/Tim Jack

ISSN 2511-2708

Note
External contributions do not necessarily reflect the opinions of the
Robert Koch Institute.

The Robert Koch Institute is a Federal Institute within
the portfolio of the German Federal Ministry of Health