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Petersen, Jindong Ding; Kyvik, Kirsten Ohm; Heitmann, Berit Lilienthal; Vámosi, Marianne

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## ORIGINAL ARTICLE

# The association between parental separation during childhood and obesity in adulthood: a Danish twin study

J. D. Petersen<sup>1,2</sup>, K. O. Kyvik<sup>3,4,5</sup>, B. L. Heitmann<sup>2,6,7,8</sup> and M. E. Vámosi<sup>9</sup>

<sup>1</sup>Research Unit for General Practice, Department of Public Health, University of Southern Denmark, Odense C, Denmark; <sup>2</sup>Research Unit for Dietary Studies at the Parker Institute, Bispebjerg and Frederiksberg Hospital, Copenhagen, Denmark; <sup>3</sup>Department of Clinical Research, University of Southern Denmark, Odense, Denmark; <sup>4</sup>Odense Patient Data Explorative Network, Odense University Hospital, Odense, Denmark; <sup>5</sup>The Danish Twin Registry, Epidemiology, Biostatistics and Biodemography, Institute of Public Health, University of Southern Denmark, Odense, Denmark; <sup>6</sup>The Boden Institute of Obesity, Nutrition Exercise and Eating Disorders, University of Sydney, Australia; <sup>7</sup>The National Institute of Public Health, University of Southern Denmark, Denmark; <sup>8</sup>Department of Public Health, Section for General Practice, University of Copenhagen, Denmark; <sup>9</sup>Institute of Public Health, Department of Nursing Science, University of Aarhus, Denmark;

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Address for correspondence: JD Petersen, Research Unit for General Practice, Department of Public Health, University of Southern Denmark, J.B. Winsløvs Vej 9, 5000 Odense C, Denmark. E-mail: dingjindong@gmail.com; jindong@health.sdu.dk

## Summary

### Objective

The purpose of this study was to examine if parental separation during childhood is associated with obesity in adulthood.

### Methods

A co-twin case-control study of 146 adult same-sexed twin pairs with discordant body mass index (BMI) (i.e. one of the twins should have a BMI of 20–25 kg/m<sup>2</sup>, and the co-twin's BMI  $\geq$  30 kg/m<sup>2</sup>) was selected from Danish Twin Registry (DTR). In total of 236 eligible twin individuals participated in the study. Childhood parental separation (defined as separation from one of the biological parents, regardless of the reason for separation) for at least one year prior to age 17 was self-reported. The statistical analysis includes logistic and linear regression models using STATA 13.0.

### Results

There were no differences in the odds of developing obesity in adulthood between the twin who stayed with a father and the co-twin who was separated from him for at least 1 year prior to age 17 [OR = 1.22, 95%CI (0.46–3.34),  $p = 0.65$ ]. Separation from a mother also showed no differences in the odds for developing obesity [OR = 0.90, 95%CI (0.32–2.46),  $p = 0.82$ ].

### Conclusions

Because of the limited number of discordant twin pairs for childhood parental separation, we cannot provide evidence to suggest that separation from parents in childhood was associated with developing obesity in adulthood. Further studies of pooling discordant twins from several countries should be considered.

**Keywords:** Adulthood, childhood, epidemiology, obesity, parental separation.

## Introduction

A series of recent meta-analysis of epidemiological studies found that childhood adversities, such as physical and sexual abuse in early life, were associated with the development of obesity in adulthood (1,2), whereas evidence linking emotional adversities in childhood to adulthood obesity still remains controversial (3–5).

Long-term separation from a parent is one of the most common childhood emotional adversities, according to the World Health Organization (WHO) World Mental Health Surveys conducted in 21 countries (including 10 in Europe) (6). Also, over the past decades, the proportion of single-parent households has increased worldwide, primarily consisting of single-mother homes (7,8). Earlier findings suggested that parental separation experienced

during the prenatal phase may lead to overweight and obesity during childhood (9–11). However, relatively little is known about whether long-term separation from a parent during childhood poses a higher risk of developing obesity in adulthood, given that such separation may cause the child immediate and acute emotional harm, including stress.

An American study with 29,229 adult subjects from among the general population investigated the pathways from childhood abuse and other adversities to adult health risk and found that parental separation was directly and significantly associated with adult obesity ( $p < 0.001$ ) (12). Other studies have failed to confirm this finding (13,14). There are, however, potential limitations to such studies, including confounding from socioeconomic and genetic heterogeneity. Given that the heritability of obesity can vary from 40% up to 70% in different populations (15), it is likely that genetic factors somehow modify the association between parental separation and long-term development of obesity.

The use of discordant twin study designs, such as the co-twin case–control study, is a useful method for gaining information about the relationship between parental separation and risk for adulthood obesity, as shared genetic and environmental factors are accounted for statistically (16,17). The co-twin case–control design was previously used to demonstrate that being exposed to maternal neglect or being bullied by peers at school was related to later development of obesity, independent of genetic or shared family environment (18,19).

In the present co-twin case–control study, we examine if parental separation (defined as separation from one of the biological parents, regardless of the reason for separation) for at least one year prior to age 17 is related to the development of obesity in adulthood, and whether the duration of separation is correlated with the BMI differences between BMI discordant adult twins, controlling for potential genetic, as well as environmental factors including parent's socioeconomic status, parental educational levels and lifestyle before the separation occurred.

## Method and procedure

### Database

The DTR is the oldest national twin registry in the world, spanning a period of almost 140 years, covering all birth cohorts of twins from 1870 to 2010 (17). Nationwide large-scale self-administered questionnaire surveys have been conducted in 1966, 1994, 2002 and 2003 among twins from the registry. The present study samples were selected based on the survey from 2002

(i.e. the Omnibus 2002 twin cohort study). The Omnibus study is described in detail elsewhere (19). In brief, a total of 46,418 twin individuals in the DTR (aged 20–71 years) were targeted for survey in 2002. After one reminder, a total of 34,944 (75.3%) individuals returned their self-reported questionnaires, with information on body weight and height. The BMI of each individual was calculated according to the WHO BMI calculation (i.e.  $\text{kg/m}^2$ ) (20).

### Present study samples

The cases in this study were obese twins, while the controls were their co-twins with normal BMI. The twins who fulfilled the following criteria were eligible for this study: (i) the twin pair were discordant for BMI in 2002, i.e. one twin was obese with  $\text{BMI} \geq 30 \text{ kg/m}^2$ , the co-twin was normal weight with BMI between 20 and  $25 \text{ kg/m}^2$  (i.e. intra-pair BMI difference  $\Delta \geq 5 \text{ kg/m}^2$ ); (ii) the twins in a pair were of the same sex; (iii) the twins were aged between 20 and 50 in 2002. In addition, as discordance for obesity in twin pairs is rare, both monozygotic (MZ) and dizygotic (DZ) twin pairs were included to increase the study power. In addition, none of the subjects included reported having been obese before age 7.

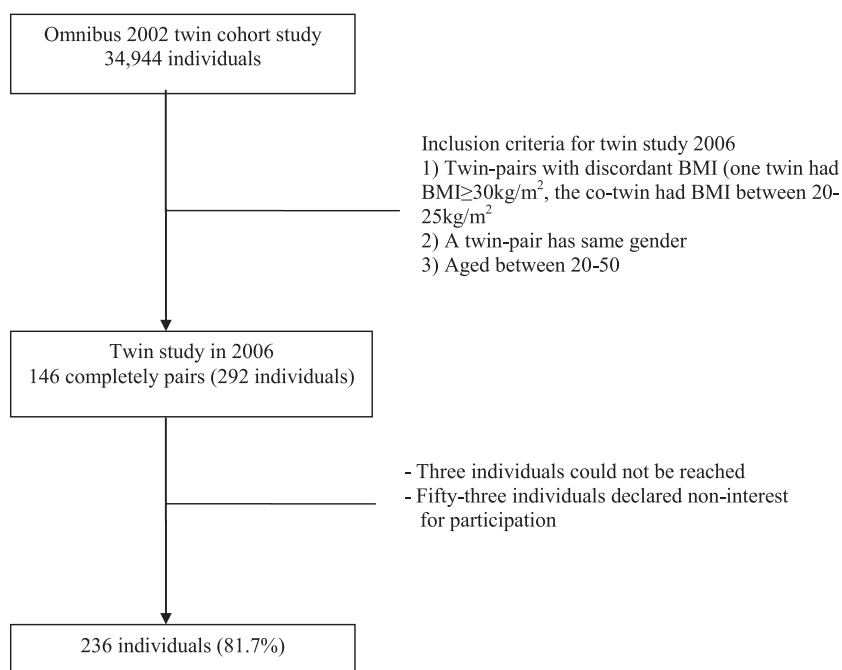
### Recruiting procedure

There was a total of 146 twin pairs (292 individuals) that fulfilled the inclusion criteria and were eligible for the present study. An invitation to participate, including detailed information about the study, was sent to the twins' home addresses in 2006. Those who did not reply to the initial letter were followed-up by phone. Of the 292 twin individuals contacted, 53 declined to participate in the study and 3 could not be reached; 236 persons (81.7%), including 109 complete twin pairs, consented and subsequently underwent a structured interview and a physical examination in 2006 (Figure 1). The structured interview took place either at the participant's home or at the closest nursing college, depending on the interviewee's preference. Approximately 1.5 to 2 h, on average, was used to complete each interview and physical examination.

The study was approved by the Scientific Ethical Committees of Vejle and Funen (J nr VF-20030155).

### The Childhood Experience of Care and Abuse Questionnaire (CECA.Q)

The structured interview consisted of a total of 145 questions from nine validated questionnaires, covering various health-related topics (for detailed information regarding the health-related topics, please refer to our earlier



**Figure 1** The flow of the study sample selection.

studies) (18,19). Childhood parental care was included as one of the topics in the interview by using the Childhood Experience of Care and Abuse Questionnaire (CECA.Q).

The CECA.Q was initially developed and validated by Bufilco *et al.* and is a questionnaire that assesses, among other items, the perception of lack of parental care, parental physical abuse and parental separation before age 17 by retrospective interview, and has been found to be highly predictive of psychiatric disorder in adult life (21).

The question regarding parental separation during childhood was extracted from the questionnaire for the present study. The question was phrased: 'Have you ever been separated from your mother/father for at least one year before the age of 17 years?' When subjects answered affirmatively, an additional question regarding the length of the separation in years followed. Subjects were also asked at which age the first separation from their parents occurred, and what the reason for the separation was. To this latter question, the possible answers included parental divorce/separation, and parental death as well as ever being placed in a children's home and also specified whether the separation was maternal or paternal. However, because of sample size limitations, we analysed the association between parental separation during childhood and adulthood obesity regardless of the reason for the separation.

### Physical examination

The participants' body weight and height were measured during the interview. The same folding rule and bathroom scale was used for all participants. The same trained researcher conducted all the measurements. The participants were required to wear thin indoor clothes and no shoes for the physical examination. Body height was measured in centimetre (cm), and body weight was measured in kilogrammes (kg) to one decimal place. Individuals were categorized as being normal weight, overweight or obese based on the WHO BMI classification (20).

### Statistical analysis

Descriptive analysis of age, sex, zygosity and experiences of parental separation was performed. The association between separation from a parent and adulthood obesity was performed with intra-pair analysis based on McNemar's test. For this test, only discordant twin pairs are informative. The test compares the number of discordant twin pairs in which the case was exposed, to the number of discordant twin pairs in which the control was exposed. The odd ratios (ORs) with 95% confidence interval (95% CI) and the *p* values for these tests are reported.

The difference in the duration of exposure from parental separation and the mean BMI differences between the cases and controls were analysed by linear regression. STATA 13.0 (StataCorp, College Station, TX, USA) software was used for all the statistical analysis.

## Results

A total of 236 twin individuals including 109 complete twin pairs and 18 individuals completed the interview and physical examination in 2006. Of those, 77 were males, with a mean age of 40.4 years, and 159 were females, with a mean age of 41.4 years (Table 1). The majority of twin pairs were DZ (72.0%).

In total, 61 (25.8%) individuals reported being separated from their father, and 49 (20.8%) reported being separated from their mother for at least one year prior to age 17 (Table 1). For those who experienced separation, the average age of first separation was slightly earlier (unpaired *t*-test  $p = 0.11$ ), and the average duration was longer (unpaired *t*-test  $p = 0.01$ ) for individuals separated from their fathers' compared to the individuals separated from their mothers'. We excluded parental loss (loss mother  $n = 4$ , loss father  $n = 16$ ) for the further intra-pair analysis, as the numbers were too small.

**Table 1** Descriptive statistics of the study participants.

	Male	Female
Numbers (%)	77 (32.6)	159 (67.4)
Zygoty (complete pairs)		
Monozygotic	13 (6)	45 (21)
Dizygotic	64 (30)	106 (48)
Unknown	0	8 (4)
Mean age in 2006 (years) (sd)	40.4 (8.4)	41.4 (7.3)
Mean BMI in 2002 (kg/m <sup>2</sup> )	27.3 (4.4)	28.4 (7.1)
Mean BMI in 2006 (kg/m <sup>2</sup> )	28.8 (4.8)	29.5 (6.8)
<i>Life events experiencing prior to age 17</i>		
Lived in children's home		
Number of experienced	8	14
Mean age (sd) <sup>a</sup>	—	—
Mean length/years (sd) <sup>b</sup>	1.8 (1.1)	1.9 (2.3)
Separated from mother <sup>c</sup>		
Number of experienced	18	31
Mean age (sd) <sup>a</sup>	12.5 (3.9)	12.8 (5.0)
Mean length/years (sd) <sup>b</sup>	3.2 (3.2)	1.8 (1.4)
Separated from father <sup>c</sup>		
Number of experienced	20	41
Mean age (sd) <sup>a</sup>	11.8 (5.6)	10.7 (6.0)
Mean length/years (sd) <sup>b</sup>	4.5 (5.6)	4.5 (5.6)

<sup>a</sup>Mean age at the first separation of the twin individuals who answered this question.

<sup>b</sup>Mean length for the separation of the twin individuals who answered this question.

<sup>c</sup>Separation for one year or more.

## Intra-pair analysis results

A total of 109 BMI discordant twin pairs were included in the intra-pair analysis. The pairs with missing information for one or both co-twins were excluded from the analysis. Very few discordant pairs who experienced parental separation before age 17 were available for analysis (Table 2).

Intra-pair analysis of parental separation resulted in similar odds for developing obesity in adulthood regardless of whether or not a twin had been separated from their father [OR = 1.22, 95%CI (0.46–3.34)] or mother [OR = 0.90, 95%CI (0.32–2.46)] for at least 1 year prior to age 17 (Table 2). Similar odds were also observed for twins who had experienced any parental separation (either from father or mother, or ever placed in a nursing home) compared to the co-twins who had not experienced such separation for at least 1 year prior to age 17 [OR = 1.11, 95%CI (0.41–3.09)].

The intra-pair analysis by zygosity indicated that, the MZ twins had a higher, but not statistically significant risk of developing obesity among the twins who had experienced separation compared to the co-twin without such experience (Table 2).

## Linear regression analysis results

Length of separation was also unrelated to adult obesity. Among those twins who had been separated from their father prior to age 17, for every one-year separation the mean BMI difference increased by 0.24 kg/m<sup>2</sup> (Table 3), but this difference was not significant. Similar non-significant findings were observed in relation to maternal separation. The results were essentially similar whether BMI from 2002 or 2006 was used.

## Discussion

In the present study, we examined whether separation from parents during childhood is a risk factor for developing adult obesity; after taking shared genetic and environmental factors into account, our results suggest that there was no evidence to support such an association.

Few studies have reported on childhood parental separation and adulthood obesity, although parental separation in childhood has previously been linked to poorer mental and physical health in adulthood, and even to stress biomarkers (14,22,23). Lacey *et al.* compared 7,462 British with a similar age range, social welfare and health care as our study, and found no significant mean BMI difference at age 42 between those adults who had experienced parental separation in childhood (0–16 years) and those who had not ( $p > 0.05$ ) (14).

**Table 2** McNemar's test of association between occurrence of events prior to age 17 and BMI discordant in 2002 of all<sup>a</sup>, monozygotic (MZ) and dizygotic (DZ) twin pairs

Life events prior to 17	All twin pairs (DZ + MZ + Unknown)					DZ twin pairs					MZ twin pairs					
	Nr.of exposed <sup>a</sup> (case)	Nr.of exposed <sup>a</sup> (control)	Chi(2)	OR (95% CI) P	Nr.of exposed <sup>a</sup> (case)	Nr.of exposed <sup>a</sup> (control)	Chi(2)	OR (95% CI) p	Nr.of exposed <sup>a</sup> (case)	Nr.of exposed <sup>a</sup> (control)	Chi(2)	OR (95% CI) p	Nr.of exposed <sup>a</sup> (case)	Nr.of exposed <sup>a</sup> (control)	Chi(2)	OR (95% CI) p
Lived in a children's home (n = 22)	4 (11)	4 (11)	0.00	1.00 (0.19–5.37) 1.00	2 (5)	3 (6)	0.20	0.67 (0.06–5.82) 0.65	1 (4)	1 (4)	0.00	1.00 (0.13–78.50) 1.00	1 (4)	1 (4)	0.00	1.00 (0.13–78.50) 1.00
Separation from mother (n = 49)	9 (23)	10 (24)	0.05	0.90 (0.32–2.46) 0.82	6 (15)	8 (17)	0.29	0.75 (0.21–2.46) 0.59	2 (6)	1 (5)	0.33	2.00 (0.10–117.99) 0.56	2 (6)	1 (5)	0.33	2.00 (0.10–117.99) 0.56
Separation from father (n = 61)	11 (29)	9 (27)	0.20	1.22 (0.46–3.34) 0.65	7 (19)	7 (19)	0.00	1.00 (0.30–3.34) 1.00	3 (8)	1 (6)	1.00	3.00 (0.24–157.49) 0.32	3 (8)	1 (6)	1.00	3.00 (0.24–157.49) 0.32
Any separation <sup>a</sup> (n = 70)	10 (33)	9 (32)	0.05	1.11 (0.41–3.09) 0.82	7 (23)	7 (23)	0.00	1.00 (0.30–3.34) 1.00	3 (8)	1 (6)	1.00	3.00 (0.24–157.49) 0.32	3 (8)	1 (6)	1.00	3.00 (0.24–157.49) 0.32

<sup>a</sup>Including DZ, MZ and unknown twin pairs.

<sup>b</sup>Discordant twin pairs which the twin (case) had experienced, but the co-twin (control) had not experienced.

<sup>c</sup>Discordant twin pairs which the twin (control) had experienced, but the co-twin (case) had not experienced.

<sup>d</sup>Either experienced mother, father or lived in a children's home.

**Table 3** Linear regression between differences in BMI in 2002 and 2006 and the time length of events, case and control

Differences in BMI	Coef.	Std. err	<i>t</i>	<i>p</i>	95%CI
In 2002					
Differences in time length at children's home	0.57	1.27	0.45	0.66	−1.94 3.07
Differences in time length from mother separation	−0.29	0.83	−0.34	0.73	−1.92 1.35
Differences in time length from father separation	0.24	0.51	0.47	0.64	−0.78 1.26
In 2006					
Differences in time length at children's home	0.77	1.17	0.66	0.51	−1.54 3.08
Differences in time length from mother separation	−0.45	0.76	−0.59	0.55	−1.96 1.06
Differences in time length from father separation	0.09	0.47	0.18	0.86	−0.85 1.03

A Finnish clinical cohort study of 1,361 adults with normal BMI, born in Helsinki during 1934–1944, examined early life stress from parental separation and blood pressure in late adulthood. They reported no significant BMI difference, regardless of whether or not subjects had been exposed to such adverse experiences in childhood, although the separation was mainly because of the Cold War (13). Our results are consistent with these previous findings.

Our study focused on childhood parental separation only, while other studies have shown that the clustering of adversities increases the risk of bad health outcomes (12,24–26), particularly adversities like abuse and parental loss (12). For instance, one study reported that the odds of being morbidly obese (BMI > 40) in adulthood was threefold higher for those who had experienced more than four adverse childhood experiences compared to those experiencing zero events, but, no higher odds were observed for those who had experienced one event than those who had experienced zero events (27).

An explanation for the lack of a relationship between childhood parental separation and adulthood obesity may be because of the fact that parental separation has less psychological negative effects (e.g. stress) than sexual or physical abuse. Indeed, a meta-analysis of 42 studies among adult U.S. populations revealed that childhood adversities such as parental divorce and imprisonment resulted in only one psychiatric outcome, while other adversities, including physical and emotional abuse, were associated with all psychiatric outcomes measured (28).

Also, the timing of childhood adversities may have different effects on later life health. In agreement, a Korean cohort study reported that childhood adversities, including parental death and parental divorce, occurring before age 12 may have more severe effects on later life health than those occurring after age 12 (29). However, in the present study, we did not have a sufficient number of cases to separate early events from later ones.

Denmark has an advanced social welfare system. Various free-of-charge social programmes are available and equitable to single parents, as well as to children with

special needs (30). Those social support systems may lessen the adverse health consequences caused by parental separation.

Our present study has some limitations. The data regarding childhood adversities was based on self-reported information. Individuals suffering from obesity or other health problems in adulthood may report experiences of childhood adversities differently than healthy and normal-weight individuals (25). However, parental separation is probably not a sensitive issue to report compared to other adversities such as physical and sexual abuse. Also, when they were asked for their perception of their weight changes, none of the twins considered childhood adversities to be the reason for them being overweight. We thus do not believe that there is serious recall bias.

Although we had 109 twin pairs discordant for BMI for our analysis, but being discordant both for BMI and for parental separation is rare. This means that we had very few MZ twin pairs with the relevant information for the intra-pair analysis, resulting in extremely wide confidence intervals, and the study is therefore under-powered. However, the 109 obesity discordant twin pairs in this study represent the maximum number of twin pairs we could obtain, and to the best of our knowledge, the number of twin pairs discordant for BMI in our study is among the largest cohort worldwide for a single country. There are potential possibilities for pooling discordant twins from other countries, such as the Nordic countries. Also, the sibling study design may prove to be useful for examining whether parental separation before a specific age is related to the later development of obesity, independent of familial confounding factors. Further studies should take this suggestion into consideration.

Our study does have some advantages. The study participation rate was high (81.7%), and the study population was derived from a large population-based survey. All study participants were interviewed and examined by the same interviewer, ensuring uniform measurement across all individuals assessed. In addition, each interview involved only the interviewee and a twin individual, which prevented the answer being influenced by others.

## Conclusion

Based on our study population, there is no evidence to suggest that separation from parents in childhood is associated with obesity in adulthood. Nevertheless, understanding the role of separation from a parent in childhood in the development of adulthood obesity is particularly important, given that the prevalence of single-parent households in many countries is increasing and the rate of obesity is high. Hence, further pooled studies or studies using sibling design are needed to examine this in greater detail.

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## Conflict of interest statement

All authors declare no conflict of interest.

## Author contributions

Kirsten Ohm Kyvik (KOK) and Marianne Eva Vámosi (MV) collected data. MV and Berit Lilienthal Heitmann (BLH) initiated the project and Jindong Ding Petersen (JDP) performed all the statistical analysis and was in charge of writing. All the authors contributed to the statistical analysis interpretation and provided comments on the manuscript. All the authors read and approved the final manuscript.

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