科技部補助專題研究計畫報告

肥胖對男、女生心理健康的影響是否不同？性別、肥胖、自殺傾向與憂鬱：臺灣與英國青少年之世代研究(第2年)

報 告 類 別 ： 成果報告
計 畫 類 別 ： 個別型計畫
計 畫 編 號 ： MOST 108-2629-B-002-002-MY2
執 行 期 間 ： 109年08月01日至110年07月31日
執 行 單 位 ： 國立臺灣大學公共衛生學院健康行為與社區科學研究所

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本研究具有政策應用參考價值：■否 □是，建議提供機關
（勾選「是」者，請列舉建議可提供施政參考之業務主管機關）
本研究具影響公共利益之重大發現：□否 □是

中 華 民 國 110 年 10 月 27 日

中 文 摘 要 ： 目的：本二年計畫的目的為：（1）了解肥胖對青少年自殺與憂鬱的影響及其性別差異；（2）了解身體意象是否為肥胖影響青少男、女自殺與憂鬱的中介因子；（3）了解肥胖對青少年自殺與憂鬱影響在台灣與英國的差異。

方法：使用兩個世代追蹤研究：台灣兒童與青少年行為世代追蹤研究（簡稱CABLE，10-18歲）及英國Avon親子長期追蹤研究（簡稱ALSPAC，0-17歲），樣本各約2500和5000人。心理健康相關變項（自殺想法、自我傷害、憂鬱）在16-18歲間測量；身體質量指數（BMI）分別在15-16歲（CABLE）或在5、10和15歲（Avon）測量。身體質量指數和心理健康變項間之關係，以及身體意象在其中的中介效果使用羅吉斯迴歸模型來分析，並探討性別與身體質量指數的交互作用。

結果：以兒童與青少年行為世代追蹤研究的資料分析發現，在控制共變項後，青少年於15-16歲時的BMI z值較高或分類為肥胖者，相較於BMI z值較低或分類為正常者對於17-18歲時自殺意念的發生有保護作用（即勝算比小於1），而女性、不滿意體型程度、體型壓力程度則與自殺意念有正相關（危害作用，即勝算比大於1）。由性別分層分析可發現，青少年男性的肥胖情況與BMI值皆和自殺意念呈現負相關（具保護作用），不滿意體型程度及體型壓力則與自殺意念呈正相關（具危害作用）；對青少年女性來說，BMI對於自殺意念沒有影響，而體型壓力與自殺意念呈現正相關（具危害作用）。另外，使用英國Avon親子長期追蹤研究的資料分析發現，5、10和15歲時身體質量指數較高與16-17歲時較高自我傷害和憂鬱風險有關聯（危害作用），但此關聯在控制社會經濟和生活型態因素後減弱。兩個世代研究的資料皆無顯示BMI對於青少年心理健康的影響有統計上的差異。

結論：我們發現心理健康問題（自殺想法、自我傷害、憂鬱）常見於台灣與英國的青少年族群，發生風險具有性別差異。身體質量指數與心理健康有關，但在男、女生中，及台灣與英國間的影響不完全相同。此外，在預防青少年自殺行為與憂鬱時，不滿意體型程度和自覺體型壓力可能較身體質量指數的重要性更高。

中 文 關 鍵 詞 ： 性別、肥胖、身體質量指數、憂鬱、自殺、自傷、青少年、世代研究

英 文 摘 要 ： Objectives: This two-year study was aimed to (1) investigate the effect of body weight on adolescent suicidality and depression and any gender differences; (2) examine the mediation effect of body perception in the pathway from obesity to suicidality and depression in boys and girls; and (3) identify any differences in the link between obesity and suicidality and depression among adolescents from Taiwan and the United Kingdom (UK).

Method: This project used data from two cohort studies, the

Child and Adolescent Behaviors in Long-term Evolution (CABLE, ages 10-18 years), Taiwan (n=~2500), and the Avon Longitudinal Study of Parents and Children (ALSPAC, ages 0-17 years), UK (n~=5000). Information of poor mental health (suicide ideation, self-harm, and depression) was measured in ages 16-18 years. Body mass index (BMI) was measured in ages 15-16 (CABLE) or at birth and ages 5, 10, and 15 (ALSPAC). Logistic regression analyses were conducted to investigate the association of BMI with mental health outcomes and the mediating role of body image in the obesity-mental health associations. Gender was included in analyses as a potential moderator.

Results: For the analysis using data from CABLE, we found that adolescents with higher BMI z score or categorized as obese were at a lower risk of suicide ideation (odds ratio <1, i.e., protecting effect) in ages 17-18. Female gender, body shape dissatisfaction, and stress with body shape were risk factors of suicide ideation. In boys, a higher BMI z score and obesity were protective factors of suicide ideation, whilst body shape dissatisfaction and stress with body shape were risk factors. In girls, there was no evidence for an association between BMI and suicide ideation, whilst greater body dissatisfaction was associated with increased risk of suicide ideation. For the analysis using data from ALSPAC, we found that there was evidence for an association of high BMI at ages 5, 10 and 15 with increased risk of self-harm and depression. These associations weakened after controlling for socioeconomic and life style factors. There was no evidence that the associations between BMI and mental health outcomes differed by gender.

Conclusion: We found that suicidality and depression were common amongst adolescents in Taiwan and the UK. BMI was associated with poor mental health outcomes, whilst there was some evidence for gender and country (the UK vs Taiwan) differences for the associations. Furthermore, we found that body shape dissatisfaction and stress with body shape may play a more important role than BMI in preventing suicidality and depression amongst adolescents.

英文關鍵詞：gender, obesity, body mass index, depression, suicide, self-harm, adolescent, cohort study

科技部專題研究計畫 (性別與科技研究計畫)

108-2629-B-002 -002 -MY2

期末報告

英文題目：Does the effect of obesity on mental health differ in boys and girls? Gender, obesity, suicidality and depression: comparative cohort studies of adolescents from Taiwan and the United Kingdom

中文題目：肥胖對男、女生心理健康的影響是否不同？性別、肥胖、自殺傾向與憂鬱：臺灣與英國青少年之世代研究

1. Background

Suicide and depression in adolescents are major public health issues which are urgently needed to be addressed (Kieling et al., 2011). The risk of suicide and depression in childhood is relatively low. When entering the adolescent period, however, the risk of suicidal behavior and depression increases significantly (Whiteford et al., 2013). In **Taiwan**, suicide is a leading cause of premature mortality; it was the second most common cause of death in the group aged 15-24 (衛生福利部, 2018). Epidemiological studies from Taiwan also showed that the prevalence of depression increased markedly during the adolescence (Gau et al., 2005). Globally, both suicide and depression are major causes of mortality and morbidity in the adolescent population (Kyu et al., 2018). Unfortunately, there is some evidence showing that adolescent mental health problems are becoming more prevalent in the 21st century (Bor et al., 2014).

One major feature of poor mental health in adolescents is gender difference. It has been shown that, when facing stress, girls are more likely to present internalizing symptoms such as depression and boys are more likely to present externalizing symptoms such as behavioral problems (Kramer et al., 2008). It is also suggested that the determinants of poor mental health differ in boys and girls, and the social norm plays an important role in the process leading to mental health problems in adolescents (Landstedt et al., 2009). When investigating risk factors and mechanisms related to the development of poor mental health in adolescents, it is therefore critical to consider the role of gender.

One of the emerging risk factors of suicide and depression is obesity (Luppino et al., 2010; Wagner et al., 2013). Nowadays, obesity is one of the most prevalent health issues. The prevalence rate increases dramatically not only among adults but also in child and adolescent populations (Afshin et al., 2017). In **Taiwan**, according to the estimates for 2017 from the Ministry of Education, the prevalence rates of overweight and obesity amongst junior high school students were 13.2% and 20.0% in boys and to 11.9% and 13.4% in girls respectively (教育部統計處, 2018). The impact of the rising prevalence of overweight and obesity on adolescent suicide and depression is worth more investigations.

However, past research shows some inconsistent findings regarding the relationship between obesity or body mass index (BMI) and suicidal tendency (or 'suicidality') and depression (Amiri & Behnezhad, 2018). Some studies found that BMI was positively correlated to depression or suicidal thoughts: the higher the BMI,

the higher risk of depression and suicidal thoughts (Bjørngaard et al., 2015; Pan et al., 2017; Strandheim et al., 2014). Other studies found that BMI was negatively correlated to suicide rate: the higher the BMI, the lower risk of suicide (Bjørngaard et al., 2015). However, the above studies were based on adult populations. One recent cross-sectional analysis of data from Chinese students suggested that only boys, but not girls, who identified themselves as underweight or obese were at increased risk of suicidal thought (Guo et al., 2019). However, such analysis was substantially limited by its cross-sectional nature, and there is an imminent need for longitudinal studies to identify any causal role of increased body weight on adolescent suicidality and depression.

Some existing studies suggested that the increased body weight may impact on adolescent mental health **through the perception and satisfaction towards own body weight**, and the mediating effect of body weight perception / satisfaction may differ in boys and girls. For example, a cross-sectional study showed that the association between obesity and depressed mood could be accounted for by body dissatisfaction in an adolescent sample (Mond et al., 2011). Furthermore, the effect of body weight on body dissatisfaction was found to differ between boys and girls (Lawler & Nixon, 2011). However, these studies were also limited by their cross-sectional design.

Cultural contexts may moderate the interrelationship between gender, obesity, and poor mental health in adolescents. The prevalence rates of obesity and the social norms towards body image may differ from countries to countries. In this study, we will use data from two cohort studies from two countries, with each representing the eastern (Taiwan) and western (United Kingdom, UK) setting. We will use longitudinal data to investigate the impact of body weight and its changes on adolescent suicidality and depression, the mediating effect of body dissatisfaction, and any differences between boys and girls and between Taiwan and the UK. The proposed longitudinal and cross-national studies will provide a better and crucial understanding into the role of gender on the relationship between obesity and adolescent poor mental health, shed light on possible causal pathways in boys and girls, and contribute to gender-informed prevention and intervention strategies aimed at reducing the risk of suicide and depression in adolescents.

2. Methods

2.1 Sources of cohort data and the participants

In this project we used cohort data from two countries in the East and West – Taiwan

and the United Kingdom (UK), i.e., the Child and Adolescent Behaviors in Long-term Evolution (CABLE) from Taiwan and the Avon Longitudinal Study of Parents and Children (ALSPAC) from the UK.

2.1.1 The Child and Adolescent Behaviors in Long-term Evolution (CABLE), Taiwan

The CABLE Project is an ongoing longitudinal cohort study that was designed to study the development of health and behaviours in children and adolescents. All elementary schools in Taipei City and Hsinchu County (representing urban and rural areas, respectively) in Northern Taiwan were stratified by school size according to first grade student numbers. Then, six small schools, two medium-sized schools and one large school from each location were randomly selected. All first-grade students in the 18 schools were selected for the sample and have been followed yearly since 2001. Informed parental consent was obtained before inclusion in the study. This study used data collected by CABLE from 2001 through 2009, with those aged 10 years at the first wave and 18 years at the seventh wave, representing participants' life stages of adolescence. Our analyses were based on data provided by the participants who completed the suicide ideation item in at least one wave in ages 17 and 18 years (n=2,360).

2.1.2 The Avon Longitudinal Study of Parents and Children (ALSPAC), United Kingdom

ALSPAC is an ongoing prospective birth cohort study in South-West England; full details of ALSPAC are available on the study website (www.bristol.ac.uk/alspac). Pregnant women resident in one of three Bristol based health districts with an expected delivery date between 1 April 1991 and 31 December 1992 were invited to participate. Of these women, 14,541 were recruited. From these pregnancies, there were 14,062 live-born children, 13,988 of whom were alive at one year. Study participants and their parents have been followed up by parent- and child-completed questionnaires, clinical attendance and links to routine data. A questionnaire containing questions of self-harming behaviours and depressive symptoms was sent to 9,384 participants at age 16-17 (mean=16.5, standard deviation=0.2); amongst them 4,855 returned the questionnaire and complete information on self-harm and depression was available for 4,707. Ethical approval was obtained from the ALSPAC Law and Ethics committee and local institutional research ethics committees.

2.2 Variables

2.2.1 Data from the CABLE study

Suicidal ideation(SI).

Suicidal thought was assessed at each follow-up point using a self-reported measure with one question: "In the past one year have you wanted to kill yourself (i.e. not wanting to live, wanting to die?)". We used information of suicide ideation that collected in ages 17-18. The answer will be coded as 1 indicating yes during 17-18 years of age and 0 indicating never answered "yes" during 17-18 years of age.

Demographic characteristics.

Child's biological sex was reported by the participant. Father's and mother's education were measured by parents' report of their highest education, ranging from junior high or below to college or above. Family monthly income was measured by the parents' report (low, medium, high). Parental divorce indicated whether the participants reported parental divorce or not at the baseline survey. Overall, approximately half of the sample were boys (50.8%), and the most frequently reported parental education level was college or above for father (54.7%) and high school for mother (46.0%). Fifteen percent and 31.5% of the participants indicated that their family income level was low and high, respectively, and 5.0% experienced parental divorce in early childhood.

Body mass index (BMI)

Measure of obesity was calculated using body mass index (BMI) as weight divided by height squared (kg/m^2). Adolescents' height and weight from the records of health examination at ages 15-16. Gender-specific BMI z score was calculated The gender-specific BMI cut-off points (https://www.hpa.gov.tw/Pages/Detail.aspx?nodeid=542&pid=9547) was also used for BMI categories as underweight, normal, overweight, and obesity.

Body image

Body shape dissatisfaction

CABLE participants were asked "How satisfied are you with your body shape?". Possible responses included "extremely satisfied", "moderately satisfied", "not an issue", "moderately dissatisfied" and "extremely dissatisfied". These responses were given a score of 0, 1, 2, 3 and 4, respectively, as the body dissatisfaction score. Body dissatisfaction was measured at age 17.

Stress with body shape

CABLE participants were asked "How much stress did you feel with your body shape?". Possible responses included "not at all", "little to moderate stress", and

"extreme stress". These responses were given a score of 0, 1, and 2, respectively. Stress with body shape was measured at age 17.

Body weight controlling behavior

CABLE participants were asked "Did you try to control your body weight?". Possible responses included "never", "yes, to gain weight", and "yes, to maintain or lose weight". Body weight controlling behavior was measured at age 17.

2.2.2 Data from the ALSPAC study

Self-harm and depression.

In a self-completed questionnaire participants were asked "have you ever hurt yourself on purpose in any way (e.g. by taking an overdose of pills or by cutting yourself)?" and "how many times have you done this in the last year? ". Those who answered yes to the first question and reported that they have self-harmed once or more in the last year were classified as subjects who had past-year self-harm. When being further asked 'Do any of the following reasons help to explain why you hurt yourself on that occasion?' those ticked the box 'I wanted to die' were classified as subjects with suicidal self-harm. The self-harm question was taken from the Childhood Interview for DSM-IV Borderline Personality Disorder (CI-BPD).(Zanarini, 2003)

Depressive symptoms were measured using the Short Moods and Feelings Questionnaire (SMFQ).(Angold et al., 1995) The SMFQ includes 13 questions asking about participants' depressive symptoms in the last two weeks. We calculated the the number of items with positive responses (i.e. the SMFQ score) for each participant and categorised those with a score 11 or more as subjects with depression.(Patton et al., 2008)

Adiposity measurements.

The ALSPAC participants' height and weight were repeatedly measured at follow-ups. Birth length was measured by the ALSPAC staff who visited newborns shortly after birth, and birth weight was extracted from medical records. Height and weight data were collected from several sources: i) routine measurements taken by health visitors (as part of standard child care in the UK) on average at 2, 10, 21 and 48 months of age; ii) parental reports from questionnaires; and iii) measurements taken at research clinics. Between ages 4 months and 5 years, length/height and weight were measured at clinics for a random 10% sample of the cohort; all children were invited to yearly clinics yearly from age 7 to 13 years and at age 15. Details of measuring equipment used in the clinics were described elsewhere.(Howe et al., 2010) Measures of

adiposity were calculated as follows: ponderal index (PI) as weight divided by height cubed (kg/m3) and body mass index (BMI) as weight divided by height squared (kg/m2).
In this study we investigated the associations of adiposity measured at ages 0, 5, 10 and 15 with self-harm and depression at age 16-17. Time points for these adiposity measures were chosen to include different stages of life: birth, early childhood (age 5), late childhood (age 10) and adolescence at age 15, when the most recent data for body height/weight measurements were available before outcomes were recorded. The gap between the last exposure (assessed at age 15) and outcomes (assessed at age 16-17) made reverse causality unlikely.

Potential confounders.
Data for the following potential confounding factors was extracted from the ALSPAC questionnaires: parental social class (based on the lower of the mother or partner's social class) and maternal education (highest educational level) for which information was collected when the participant was born; an 'equivalised' household income measure(Gregg et al., 2008) expressed in quintile, based on average income level information collected at 33 and 47 months follow-ups, accounting for family size and composition and estimated housing benefits; ethnicity as reported by the mother prior to birth; smoking, alcohol drinking and exercise from questions included in the same questionnaire as the self-harm/depression data. Data for participants' performance in national examinations (GCSEs/GNVQs) undertaken at age 15/16 years were obtained by links to national records.

2.3 Statistical methods

2.3.1 Analysis using data from the CABLE study

Logistic regression analyses were conducted to investigate the association of BMI with mental health outcomes and the mediating role of body image in the obesity-mental health associations. The analyses were conducted for boys and girls combined and also separately. In the analysis including both boys and girls participants, *BMI*gender* variable was included in analyses for examining gender interaction (i.e., whether gender is a moderator). All analyses were conducted using SAS statistical software 9.4 (SAS Institute Inc., Cary, NC, USA).

2.3.2 Analysis using data from the ALSPAC study

For adiposity measures at ages 0, 5 and 10 we used data derived from individual trajectories of PI/BMI estimated using mixed-effects linear spline models. This approach has the advantages of allowing us to use all available information on

length/height and weight for all children in the ALSPAC cohort and to estimate PI/BMI at specific ages based on individual trajectories. The details of model construction and estimation were described elsewhere.(Howe et al., 2010; Howe et al., 2011) In brief, such models allow for individual variation in trajectories as random effects allow each child to have different intercepts and slopes. Changes in scale and variance of PI/BMI between birth and 10 years were modelled, under a missing at random assumption. Models were constructed for PI from birth to age 2 and for BMI from age 2 to 10, for boys and girls separately. PI, instead of BMI, was used as the measure of adiposity from birth to 2 years because patterns of BMI change in early childhood are highly complicated. Modelling BMI trajectories beyond age 10 was not considered since the growth trajectories over puberty would be complex due to variation in age at puberty onset. Individual trajectories of PI (aged 0-2 years) were modelled for 12,246 participants and BMI (aged 2-10 years) for 11,380 participants.(Howe et al., 2011)

BMI z scores (at ages 5, 10 and 15) relative to the UK 1990 BMI population reference data(Cole et al., 1995) were calculated; these were grouped into quartiles and also categorised into three groups: normal weight (BMI z score <1.04, below the 85th percentile), overweight (BMI z score >=1.04 <1.64, equivalent to 85th-94th percentiles) and obese (BMI z score >=1.64, equivalent to >=95th percentile), in keeping with previous studies.(Hughes et al., 2011) The UK 1990 population reference data do not include PI at birth and thus sex-specific z scores for PI were calculated as the number of standard deviations above (positive values) or below (negative values) the mean and were grouped into quartiles.

We used logistic regression models to estimate odds ratios of self-harm/depression for one standard deviation [SD] increase in PI/BMI z score. Odds ratios for PI quartiles (using the lowest quartile as reference) and for overweight and obesity defined by BMI (using normal weight as reference) were also calculated. To examine whether associations differ by sex we included interaction terms in the models. To investigate evidence for non-linear associations we included quadratic terms of z scores of PI/BMI. In multivariable models we investigated the effect of controlling for potential confounders on the association.

Sensitivity analyses were conducted using imputed datasets based on participants with complete outcome data, to investigate the possible effect of missing data on PI/BMI and potential confounders on associations with self-harm/depression. We used multiple imputation by chained equations (MICE)(Royston, 2005) to create multiple copies of datasets in which missing data were replaced by imputed values; these imputed values were sampled from their posterior predictive distributions obtained from prediction models that included variables related to missing data. We used 48

variables in the imputation model, including those in the main analyses (outcomes and exposures of interest and potential confounders) and additional variables that were shown previously to be associated with loss of follow-up in this cohort, such as the socioeconomic position variables collected during pregnancy,(Spratt et al., 2010) or related to our exposures of interest, such as parental BMI and parent- or child-reported height and weight from questionnaires completed around age 15. Multiple imputation was conducted using the *ice* command in Stata(Royston, 2005) and 40 imputed datasets were generated. Results of analyses based on each dataset were combined using Rubin's rules(Little & Rubin, 2002) through the Stata command *mim*. We compared results based on imputed datasets and those restricted to participants with complete data ('complete-case analyses'). All analyses in this study were conducted using Stata, version 12.

3. Results

3.1 Results from CABLE data

Table 1 shows the associations of factors of suicide ideation in ages 17-18 amongst participants (boys and girls combined). In the unadjusted analyses, we found that adolescents with greater body shape dissatisfaction, little to moderate or extreme stress with body shape, and ever tried to maintain or lose weight were at increased risk of having suicide ideation in ages 17-18 ($p<0.001$). The odds ratios (ORs) and confidence intervals (95% CIs) were 1.23 (1.16-1.31), 2.28 (1.74-2.99), 4.80 (3.06-7.54), and 1.67 (1.28-2.17). There is no evidence that BMI in ages 15-16 is associated with suicide ideation in ages 17-18.

BMI was measured as gender-specific z score in adjusted model 1, whilst it was included in model 2 as a categorical variable. In the adjusted analyses, results showed that adolescents with a higher gender-specific BMI z score or those were categorized into obesity were at a lower risk of suicide ideation (i.e., protecting effects) (OR=0.85, 95% CI=0.73-0.99, p=0.031 and OR=0.61, 95% CI=0.38-0.97, p=0.035, respectively) (Table 1). Furthermore, body shape dissatisfaction and stress with body shape remained positively associated with suicide ideation risk in the adjusted analyses (i.e., risk effect).

Table 2 shows gender-specific analysis for the associations of factors of suicide ideation in ages 17-18 years; BMI was measured as gender-specific z score in adjusted model 1, whilst it was included in model 2 as a categorical variable. We found that boys with a higher BMI z score was at a lower risk of suicide ideation (OR=0.78, 95% CI=0.61-1.00, p=0.047), whilst a greater body shape dissatisfaction or moderate stress with body shape were associated with an increased risk of suicide ideation (OR=1.16, 95% CI=1.03-1.32, p=0.018 and OR=1.90, 95% CI=1.21-2.99,

p=0.005) in adjusted model 1. Similarly, boys who categorized into obesity were at a lower risk of suicide ideation (OR=0.45, 95% CI=0.21-0.95, p=0.036), whilst body shape dissatisfaction or moderate stress with body shape were associated with an increased risk of suicide ideation in adjusted model 2.

By contrast, girls with greater stress with body shape was at an increased risk of suicide ideation, whilst there is no evidence that BMI was associated with suicide ideation risk (Table 2). However, the gender interaction test showed no evidence that the association of BMI and suicide ideation differed by gender (i.e., the p values for sex*BMI interaction term > 0.10).

3.2 Results from the ALSPAC Data

Participant characteristics

Amongst 4,707 participants with complete information on self-harm and depression, 1,920 (40.8%) were males and the median age at completing the questionnaire was 16.6 years (5th-95th percentile: 16.5-17.2). The prevalence of self-harm in the last year was 16.6% (95% CI 15.5-17.6%) and the prevalence of depression in the last two weeks was 17.8% (95% CI 16.7-18.9%). The prevalence of self-harm was more than 2.5 times higher in females (22.4%, 95% CI 20.8-23.9%) than in males (8.2%, 95% CI 7.0-9.4%) and the prevalence of depression was around two times higher in females (22.7%, 95% CI 21.2-24.3%) than in males (10.6%, 95% CI 9.2-11.9%).

PI at birth was missing for 5.2% of participants; BMI at ages 5, 10 and 15 years was missing for 2.0%, 2.0% and 28% of participants respectively. Amongst those with available BMI data the proportions of participants who were overweight and obese were 11.3% and 4.9% at age 5, 12.8% and 9.5% at age 10, and 12.9% and 11.2% at age 15. These proportions were similar in males and females.

Complete data on PI/BMI and potential confounders were available for 2,432 (51.7%) participants. Males were more likely to have complete data than females (53.6% versus 50.3%). Characteristics of the 4,707 participants are shown in Table 3. For those who had self-harmed in the last year or were depressed in the last two weeks, they were both more likely to be female, have lower socioeconomic position according to parental social class, maternal education or household income, have poorer academic performance, smoke and drink more and exercise less, compared with those who had not self-harmed or were not depressed (all $p < 0.05$). Participants who had self-harmed in the last year were nearly four times more likely to be depressed in the last two weeks than those who had not self-harmed (45.1% versus 12.4%).

Adiposity and self-harm

Based on participants with complete data, there was little evidence for an association of PI at birth with self-harm at age 16-17 in both sex-adjusted models and models controlling for all potential confounders (Table 4). High BMI z scores at ages 5, 10 and 15 years were associated with increased risk of self-harm in sex-adjusted models although associations weakened around 20-25% when controlling for potential confounders. In fully adjusted models odds ratios (ORs) per one standard deviation increase in BMI at ages 5, 10 and 15 years were 1.16 (95% CI 1.03-1.31), 1.22 (95% CI 1.10-1.35) and 1.18 (95% CI 1.07-1.31) respectively. Overweight participants at age 5, 10 and 15 years showed 12-41% increases in risk and the obese showed 37-62% increases in risk when all potential confounders were controlled for, although 95% confidence intervals were wide. There was no statistical evidence for sex differences (all p for interaction term >0.1), although analyses stratified by sex suggested stronger associations in females than in males for BMI at ages 15 years – in fully adjusted model, one standard deviation increase in females' BMI at age 15 was associated with a 17% (95% CI 4-32%) increase in self-harm risk but there was limited evidence for an association in males (p for interaction term =0.30). There was weak evidence for a J-shaped association between BMI at age 10 and self-harm (p for quadratic term =0.057), with risk increasing only for the group of the highest BMI quartile compared to the lowest quartile (data not shown).

Adiposity and depression

Analyses based on participants with complete data showed that there was evidence for an association of high BMI z scores at ages 5, 10 and 15 years with increased risk of depression at age 16-17, whilst there was no evidence for such an association for PI at birth (Table 5). Associations showed in sex-adjusted models were attenuated 15-35% after controlling for all potential confounders in fully adjusted models. Fully adjusted odds ratios per one standard deviation increase in BMI at ages 5, 10 and 15 years were 1.13 (95% CI 1.00-1.17), 1.12 (95% CI 1.01-1.24) and 1.14 (95% CI 1.03-1.26) respectively. Overweight and obesity at ages 5, 10 and 15 were associated with 4-22% and 6-34% increases in risk of depression respectively despite wide confidence intervals. There was no strong evidence for sex differences (all p for interaction term >0.1) or quadratic relationships (all p for quadratic term >0.1).

Multiple imputation

Analyses based on imputed datasets generally showed consistent but weakened associations, particularly for BMI at age 5, compared to those based on participants with complete data only. In fully adjusted models, odds ratios per one standard

deviation increase in BMI at ages 5, 10 and 15 were 1.03 (95% CI 0.94-1.13), 1.10 (95% CI 1.01-1.18) and 1.08 (95% CI 1.00-1.17) for self-harm (Table 6) and 1.06 (95% CI 0.97-1.15), 1.05 (95% CI 0.98-1.14) and 1.08 (95% CI 1.00-1.16) for depression (Table 7) respectively. There was weak evidence for stronger associations in females than in males for the association of BMI at age 15 with self-harm (p for interaction term =0.25) and the associations of BMI at ages 10 and 15 with depression (both p for interaction term=0.20).

4. Conclusion

We found that suicidality and depression are common among adolescents in Taiwan and the UK. BMI is associated with poor mental health outcomes, whilst there was some evidence for sex and country (the UK vs Taiwan) differences for the associations. Furthermore, we found that body shape dissatisfaction and stress with body shape may play a more important role than BMI in preventing suicidality and depression amongst adolescents.

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Tables

Table 1. Factors of suicide ideation in adolescent boys and girls combined.

	Y=suicide ideation (yes/no)											
	Unadjusted				Adjusted model 1				Adjusted model 2			
	OR	95% CI		p	OR	95% CI		p	OR	95% CI		p
Gender (Ref: boy)	1.83	1.42	2.35	<0.001	1.43	1.07	1.90	0.015	1.44	1.08	1.92	0.013
Mother's education (Ref: high)												
low	1.00	0.65	1.54	0.98	0.90	0.55	1.48	0.68	0.92	0.56	1.51	0.73
medium	1.26	0.78	2.03	0.35	0.95	0.52	1.75	0.87	0.96	0.52	1.77	0.90
Father's education (Ref: high)												
low	0.97	0.64	1.47	0.87	0.77	0.48	1.24	0.28	0.78	0.49	1.26	0.31
medium	1.20	0.77	1.86	0.43	0.85	0.48	1.48	0.56	0.86	0.49	1.51	0.61
Family monthly income (Ref: high)												
low	0.99	0.68	1.44	0.96	1.06	0.70	1.58	0.80	1.04	0.69	1.56	0.86
medium	1.21	0.82	1.78	0.34	1.26	0.80	1.98	0.31	1.24	0.79	1.94	0.35
medium to high	1.44	0.90	2.31	0.13	1.50	0.86	2.62	0.16	1.45	0.83	2.54	0.19
BMI z score	1.01	0.89	1.14	0.90	0.85	0.73	0.99	0.031				
BMI category (Ref: normal)												
under weight	0.80	0.53	1.22	1.07					1.01	0.65	1.56	0.97
overweight	1.25	0.84	1.86	1.24					1.09	0.72	1.66	0.68
obesity	0.79	0.51	1.22	1.15					0.61	0.38	0.97	0.035
Body shape dissatisfaction	1.23	1.16	1.31	<0.001	1.12	1.03	1.22	0.006	1.12	1.03	1.21	0.009
Stress with body shape (Ref:no)												
little to moderate	2.28	1.74	2.99	<0.001	1.92	1.40	2.63	<0.001	1.90	1.39	2.60	<0.001
extreme	4.80	3.06	7.54	<0.001	3.47	2.02	5.95	<0.001	3.44	2.00	5.90	<0.001
Body weight controlling behavior (Ref: never)												
yes, to gain weight	1.28	0.82	2.01	0.28	0.99	0.62	1.59	0.96	1.02	0.63	1.64	0.94
yes, to maintain or lose weight	1.67	1.28	2.17	<0.001	0.92	0.66	1.28	0.61	0.88	0.63	1.23	0.46

Table 2. Factors of suicide ideation in ages 17-18 in adolescent boys and girls combined.

	Boys, Y=suicide ideation (yes/no)						Girls, Y=suicide ideation (yes/no)					
	Adjusted model 1			Adjusted model 2			Adjusted model 1			Adjusted model 2		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Mother's education (Ref: high)												
low	0.73	0.33 1.63	0.44	0.75	0.34 1.69	0.49	1.05	0.56 1.99	0.87	1.08	0.57 2.03	0.82
medium	0.61	0.23 1.66	0.34	0.64	0.24 1.74	0.38	1.29	0.59 2.82	0.53	1.31	0.60 2.88	0.50
Father's education (Ref: high)												
low	0.90	0.42 1.93	0.79	0.91	0.42 1.94	0.80	0.71	0.38 1.32	0.28	0.72	0.39 1.33	0.29
medium	1.08	0.45 2.62	0.86	1.08	0.45 2.62	0.87	0.72	0.34 1.50	0.38	0.73	0.35 1.53	0.40
Family monthly income (Ref: high)												
low	1.21	0.61 2.37	0.59	1.19	0.60 2.33	0.62	0.96	0.57 1.62	0.89	0.95	0.56 1.60	0.84
medium	1.24	0.58 2.63	0.58	1.21	0.57 2.57	0.63	1.27	0.72 2.25	0.42	1.25	0.71 2.22	0.45
medium to high	1.75	0.72 4.26	0.22	1.70	0.70 4.13	0.25	1.35	0.65 2.83	0.42	1.31	0.62 2.73	0.48
BMI z score	0.78	0.61 1.00	0.047				0.89	0.74 1.08	0.24			
BMI category (Ref: normal)												
under weight				1.05	0.58 1.89	0.88				0.99	0.51 1.90	0.97
overweight				0.78	0.39 1.53	0.46				1.40	0.81 2.41	0.23
obesity				0.45	0.21 0.95	0.036				0.74	0.40 1.36	0.33
body shape dissatisfaction	1.16	1.03 1.32	0.018	1.17	1.03 1.32	0.016	1.10	0.98 1.23	0.10	1.08	0.97 1.21	0.16
stress with body shape (Ref: no)												
little to moderate	1.90	1.21 2.99	0.005	1.91	1.22 3.00	0.005	2.01	1.30 3.13	0.002	1.98	1.28 3.08	0.002
extreme	0.86	0.23 3.21	0.82	0.85	0.23 3.19	0.81	5.03	2.55 9.91	<0.001	4.94	2.51 9.70	<0.001
body weight controlling behavior (Ref: never)												
yes, to gain weight	1.07	0.60 1.89	0.83	1.12	0.63 1.98	0.71	0.84	0.36 1.95	0.68	0.85	0.36 1.99	0.70
yes, to maintain or lose weight	0.90	0.52 1.55	0.70	0.88	0.51 1.50	0.63	0.95	0.61 1.47	0.81	0.92	0.59 1.43	0.71

Table 3. Characteristics of the participants

Characteristic2	No self-harm in the last year (N=4018) n (%)	Self-harmed in the last year (N=792) n (%)	Comparison χ^2	df	p	Not depressed in the last two weeks (N=3870) n (%)	Depressed in the last two weeks1 (N=837) n (%)	Comparison χ^2	df	p
Sex			165.3	1	<0.001			115.3	1	<0.001
Females	2,164 (55.1)	623 (79.9)				2,153 (55.6)	634 (75.8)			
Parental social class			9.0	1	0.003			4.7	1	0.03
Manual	1,364 (37.2)	312 (43.1)				1,355 (37.4)	321 (41.6)			
Maternal education			6.8	1	0.009			13.7	1	<0.001
O level or below	1,943 (50.8)	423 (56.0)				1,901 (50.4)	465 (57.6)			
Equivalised household income			11.63	4	0.02			11.51	4	0.021
Quintile 1	480 (13.4)	109 (15.3)				470 (13.3)	119 (15.9)			
Quintile 2	603 (16.9)	144 (20.2)				602 (17.0)	145 (19.3)			
Quintile 3	703 (19.6)	148 (20.8)				691 (19.5)	160 (21.3)			
Quintile 4	842 (23.5)	155 (21.8)				844 (23.8)	153 (20.4)			
Quintile 5	951 (26.6)	156 (21.9)				933 (26.4)	174 (23.2)			
Ethnicity			0.7	1	0.42			0.1	1	0.75
Non-white	161 (4.1)	27 (3.5)				153 (4.0)	35 (4.2)			
Academic performance			6.8	1	0.009			9.8	1	0.002
GCSE/GNVQ at grates A*-C: <5	2,762 (82.0)	527 (77.7)				589 (17.8)	168 (22.8)			
Smoking			172.7	4	<0.001			102.0	4	<0.001
Nonsmoker	3,258 (83.5)	493 (63.6)				3,177 (82.6)	574 (69.0)			
Less than weekly	252 (6.5)	89 (11.5)				259 (6.7)	82 (9.9)			
Weekly, less than daily	131 (3.4)	66 (8.5)				138 (3.6)	59 (7.1)			
<10 daily	182 (4.7)	78 (10.1)				196 (5.1)	64 (7.7)			
10+ daily	79 (2.0)	49 (6.3)				75 (2.0)	53 (6.4)			
Alcohol drinking			36.9	4	<0.001			21.7	4	<0.001
Never	461 (11.8)	51 (6.6)				443 (11.5)	69 (8.3)			
Monthly or less	1,360 (34.9)	247 (31.8)				1,310 (34.1)	297 (35.7)			
2-4 times a month	1,535 (39.4)	327 (42.1)				1,549 (40.4)	313 (37.6)			
2-3 times a week	481 (12.4)	127 (16.4)				480 (12.5)	128 (15.4)			
4 or more times a week	58 (1.5)	24 (3.1)				57 (1.5)	25 (3.0)			
Exercise during the past year			48.6	4	<0.001			55.3	4	<0.001
Never	185 (4.8)	39 (5.1)				178 (4.7)	46 (5.6)			
Less than once a month	186 (4.8)	73 (9.5)				177 (4.6)	82 (9.9)			
1-3 times a month	514 (13.3)	131 (17.0)				501 (13.1)	144 (17.4)			
1-4 times a week	1,974 (50.9)	385 (50.1)				1,976 (51.7)	383 (46.3)			
5 or more times a week	1,021 (26.3)	141 (18.3)				990 (25.9)	172 (20.8)			
Depression			478	1	<0.001					
Short MFQ score >=11	485 (12.4)	352 (45.1)								

[1]Missing data range from 0 (sex) to 674 (academic performance).

Table 4. Odds ratio for self-harm in the last year at age 16-17 by ponderal index (PI) at birth (by quartile and per standard deviation increase) and body mass index (BMI) at age 5, 10 and 15 (by BMI category based on the UK standard and per standard deviation increase), based on participants with complete information (N=2,432)

		Adjusted for sex			Multivariable adjustment[1]		
Covariates	Number of cases	Odds ratio	95% CI	p value	Odds ratio	95% CI	p value
PI at birth							
Quartile 1	103	Reference			Reference		
Quartile 2	107	1.05	(0.77, 1.42)		1.02	(0.74, 1.4)	
Quartile 3	98	0.94	(0.69, 1.28)		0.98	(0.71, 1.35)	
Quartile 4	100	0.97	(0.71, 1.32)		0.96	(0.7, 1.32)	
Per standard deviation (sex-specific)		1.02	(0.92, 1.13)	0.72	1.01	(0.91, 1.13)	0.83
		p for sex interaction		0.56			0.90
		p for quadratic term		0.85			0.84
BMI at age 5							
Normal weight	326	Reference			Reference		
Overweight	53	1.19	(0.86, 1.66)		1.12	(0.79, 1.57)	
Obese	29	1.63	(1.05, 2.55)		1.42	(0.89, 2.27)	
Per standard deviation (sex-specific)		1.16	(1.03, 1.31)	0.017	1.13	(0.99, 1.28)	0.06
		p for sex interaction		0.99			0.97
		p for quadratic term		0.30			0.40
BMI at age 10							
Normal weight	288	Reference			Reference		
Overweight	66	1.48	(1.09, 2.01)		1.31	(0.95, 1.81)	
Obese	54	1.81	(1.29, 2.54)		1.62	(1.14, 2.32)	
Per standard deviation (sex-specific)		1.22	(1.1, 1.35)	<0.001	1.17	(1.05, 1.3)	0.004
		p for sex interaction		0.68			0.86
		p for quadratic term		0.040			0.057
BMI at age 15							
Normal weight	288	Reference			Reference		
Overweight	66	1.44	(1.06, 1.96)		1.41	(1.03, 1.94)	
Obese	54	1.43	(1.03, 2)		1.37	(0.97, 1.94)	
Per standard deviation (sex-specific)		1.18	(1.07, 1.31)	0.001	1.14	(1.02, 1.26)	0.019
		p for sex interaction		0.22			0.30
		p for quadratic term		0.20			0.10

[1]Multivariable adjustments for sex, parental social class, mother's education, household income, ethnicity, participants' educational attainment, smoking, alcohol use and exercise.

Table 5. Odds ratio for depression in the last two weeks at age 16-17 by ponderal index (PI) at birth (by quartile and per standard deviation increase) and body mass index (BMI) at age 5, 10 and 15 (by BMI category based on the UK standard and per standard deviation increase), based on participants with complete information (N=2,432)

		Adjusted for sex			Multivariable adjustment[1]		
Covariates	Number of cases	Odds ratio	95% CI	p value	Odds ratio	95% CI	p value
PI at birth							
Quartile 1	31	Reference			Reference		
Quartile 2	41	1.04	(0.77, 1.4)		1.00	(0.73, 1.36)	
Quartile 3	37	0.92	(0.68, 1.25)		0.96	(0.7, 1.31)	
Quartile 4	19	0.93	(0.69, 1.27)		0.92	(0.67, 1.26)	
Per standard deviation (sex-specific)		0.99	(0.89, 1.1)	0.85	0.98	(0.88, 1.1)	0.77
		p for sex interaction		0.63			0.85
		p for quadratic term		0.35			0.25
BMI at age 5							
Normal weight	108	Reference			Reference		
Overweight	13	1.16	(0.83, 1.61)		1.11	(0.79, 1.55)	
Obese	7	1.52	(0.97, 2.37)		1.34	(0.84, 2.14)	
Per standard deviation (sex-specific)		1.13	(1, 1.27)	0.050	1.11	(0.98, 1.25)	0.11
		p for sex interaction		0.65			0.67
		p for quadratic term		0.11			0.19
BMI at age 10							
Normal weight	106	Reference			Reference		
Overweight	6	1.16	(0.85, 1.59)		1.04	(0.75, 1.44)	
Obese	16	1.38	(0.97, 1.95)		1.24	(0.86, 1.78)	
Per standard deviation (sex-specific)		1.12	(1.01, 1.24)	0.034	1.08	(0.97, 1.2)	0.166
		p for sex interaction		0.93			0.99
		p for quadratic term		0.54			0.79
BMI at age 15							
Normal weight	102	Reference			Reference		
Overweight	14	1.25	(0.92, 1.71)		1.22	(0.89, 1.68)	
Obese	12	1.13	(0.8, 1.6)		1.06	(0.74, 1.51)	
Per standard deviation (sex-specific)		1.14	(1.03, 1.26)	0.010	1.11	(1, 1.23)	0.059
		p for sex interaction		0.56			0.67
		p for quadratic term		0.35			0.33

[1]Multivariable adjustments for sex, parental social class, mother's education, household income, ethnicity, participants' educational attainment, smoking, alcohol use and exercise.

Table 6. Odds ratio for self-harm in the last year at age 16-17 by ponderal index (PI) at birth (by quartile and per standard deviation increase) and body mass index (BMI) at age 5, 10 and 15 (by BMI category based on the UK standard and per standard deviation increase) , using 40 imputed datasets (N=4,707)

	Adjusted for sex			Multivariable adjustment[1]		
Covariates	Odds ratio	95% CI	p value	Odds ratio	95% CI	p value
PI at birth						
Quartile 1	Reference			Reference		
Quartile 2	1.11	(0.88, 1.4)		1.10	(0.87, 1.39)	
Quartile 3	1.15	(0.92, 1.44)		1.14	(0.91, 1.44)	
Quartile 4	1.15	(0.91, 1.44)		1.13	(0.89, 1.43)	
Per standard deviation (sex-specific)	1.05	(0.97, 1.14)	0.20	1.05	(0.96, 1.14)	0.28
	p for sex interaction		0.28			0.36
	p for quadratic term		0.40			0.42
BMI at age 5						
Normal weight	Reference			Reference		
Overweight	1.02	(0.8, 1.31)		1.00	(0.77, 1.29)	
Obese	1.25	(0.89, 1.77)		1.17	(0.82, 1.67)	
Per standard deviation (sex-specific)	1.05	(0.96, 1.15)	0.27	1.03	(0.94, 1.13)	0.47
	p for sex interaction		0.84			0.81
	p for quadratic term		0.36			0.41
BMI at age 10						
Normal weight	Reference			Reference		
Overweight	1.35	(1.08, 1.69)		1.28	(1.02, 1.61)	
Obese	1.41	(1.09, 1.82)		1.31	(1.01, 1.7)	
Per standard deviation (sex-specific)	1.12	(1.04, 1.21)	0.003	1.10	(1.01, 1.18)	0.022
	p for sex interaction		0.68			0.71
	p for quadratic term		0.026			0.037
BMI at age 15						
Normal weight	Reference			Reference		
Overweight	1.27	(1, 1.62)		1.23	(0.96, 1.58)	
Obese	1.38	(1.08, 1.77)		1.30	(1.01, 1.68)	
Per standard deviation (sex-specific)	1.12	(1.03, 1.21)	0.005	1.08	(1, 1.17)	0.054
	p for sex interaction		0.19			0.25
	p for quadratic term		0.011			0.013

[1]Multivariable adjustments for sex, parental social class, mother's education, household income, ethnicity, participants' educational attainment, smoking, alcohol use and exercise.

Table 7. Odds ratio for depression in the last two weeks at age 16-17 by ponderal index (PI) at birth (by quartile and per standard deviation increase) and body mass index (BMI) at age 5, 10 and 15 (by BMI category based on the UK standard and per standard deviation increase) , using 40 imputed datasets (N=4,707)

	Adjusted for sex			Multivariable adjustment[1]		
Covariates	Odds ratio	95% CI	p value	Odds ratio	95% CI	p value
PI at birth						
Quartile 1	Reference			Reference		
Quartile 2	0.97	(0.78, 1.21)		0.96	(0.76, 1.2)	
Quartile 3	1.00	(0.8, 1.24)		1.01	(0.81, 1.27)	
Quartile 4	0.88	(0.71, 1.1)		0.87	(0.69, 1.09)	
Per standard deviation (sex-specific)	0.98	(0.9, 1.05)	0.53	0.97	(0.9, 1.05)	0.46
	p for sex interaction		0.88			0.82
	p for quadratic term		0.41			0.34
BMI at age 5						
Normal weight	Reference			Reference		
Overweight	1.25	(0.99, 1.57)		1.24	(0.98, 1.57)	
Obese	1.10	(0.77, 1.55)		1.02	(0.71, 1.46)	
Per standard deviation (sex-specific)	1.06	(0.97, 1.16)	0.19	1.06	(0.97, 1.15)	0.23
	p for sex interaction		0.62			0.60
	p for quadratic term		0.14			0.25
BMI at age 10						
Normal weight	Reference			Reference		
Overweight	1.16	(0.93, 1.44)		1.10	(0.88, 1.38)	
Obese	1.23	(0.96, 1.58)		1.15	(0.89, 1.48)	
Per standard deviation (sex-specific)	1.07	(1, 1.15)	0.066	1.05	(0.98, 1.14)	0.17
	p for sex interaction		0.21			0.20
	p for quadratic term		0.68			0.98
BMI at age 15						
Normal weight	Reference			Reference		
Overweight	1.04	(0.82, 1.33)		1.01	(0.79, 1.3)	
Obese	1.23	(0.96, 1.56)		1.15	(0.9, 1.47)	
Per standard deviation (sex-specific)	1.10	(1.02, 1.19)	0.011	1.08	(1, 1.16)	0.055
	p for sex interaction		0.14			0.20
	p for quadratic term		0.13			0.23

[1]Multivariable adjustments for sex, parental social class, mother's education, household income, ethnicity, participants' educational attainment, smoking, alcohol use and exercise.

108年度專題研究計畫成果彙整表

計畫主持人：張書森	**計畫編號：**108-2629-B-002-002-MY2
計畫名稱：肥胖對男、女生心理健康的影響是否不同？性別、肥胖、自殺傾向與憂鬱：臺灣與英國青少年之世代研究	

成果項目			量化	單位	質化 （說明：各成果項目請附佐證資料或細項說明，如期刊名稱、年份、卷期、起訖頁數、證號...等）
國內	學術性論文	期刊論文	0	篇	
		研討會論文	1		Yi-Han Chang, Hsing-Yi Chang, Lee-Lan Yen & Shu-Sen Chang (Apr 2021). The association of body mass index with adolescent suicide ideation and the gender difference. 2021 Annual Meeting of Population Association of Taiwan. 26 April 2021. Taipei, Taiwan.
		專書	0	本	
		專書論文	0	章	
		技術報告	0	篇	
		其他	0	篇	
國外	學術性論文	期刊論文	0	篇	
		研討會論文	0		
		專書	0	本	
		專書論文	0	章	
		技術報告	0	篇	
		其他	0	篇	
參與計畫人力	本國籍	大專生	0	人次	
		碩士生	0		
		博士生	0		
		博士級研究人員	1		Yi-Han Chang, Hsing-Yi Chang, Lee-Lan Yen & Shu-Sen Chang (Apr 2021). The association of body mass index with adolescent suicide ideation and the gender difference. 2021 Annual Meeting of Population Association of Taiwan. 26 April 2021. Taipei, Taiwan.
		專任人員	0		
	非本國籍	大專生	0		
		碩士生	0		
		博士生	0		
		博士級研究人員	0		

		專任人員	0		
其他成果 （無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。）			除繼續撰寫學術論文準備投稿至國際優良期刊外，本計畫也促成台灣大學與台灣國家衛生研究院和英國布里斯托大學(University of Bristol)之國際合作，未來研究團隊將持續合作使用兩個國家之大型世代追蹤計畫進行研究。		