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# Increased risk of diabetes development in individuals with weight cycling over 4years: The Kangbuk Samsung Health study

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## ABSTRACT

**Aims:** Weight cycling is defined as cyclical loss and gain of weight and recent studies suggest deleterious effects of weight cycling on cardiometabolic health. We aimed to analyze the risk for diabetes development in association with weight cycling over 4 years of follow-up.

**Methods:** A retrospective study performed in 4,818 non-diabetic participants (mean age 43 years, 78.3% men) in a health screening program in whom serial health examinations were performed in 5 consecutive years from 2010 to 2014. Average successive variability of weight (ASVW) was defined by the amount of body weight change in absolute value between the successive years over 5 years summed and divided by four. The subjects were divided into two groups according to body mass index (BMI), normal weight ( $<23 \text{ kg/m}^2$ ) and overweight ( $\geq 23 \text{ kg/m}^2$ ).

**Results:** Over 4 years, 3.2% developed diabetes. When the subjects were divided into 3 groups according to tertile groups of ASVW, those in the highest tertile showed significantly increased risk for diabetes development compared to those with the lowest tertile (odds ratio (OR) 1.860; 95% CI 1.130–3.063). When similar analyses were performed according to the 4 groups divided by baseline body weight and ASVW over four years, those who were more than overweight at baseline with high ASVW showed significantly increased risk of diabetes development compared to those had normal weight and low ASVW (OR 2.266; 95% 1.123–4.572). When the subjects were divided into six group according to weight change and ASVW, those with increased weight over 4 years and high ASVW showed the highest risk for diabetes development among the groups compared to those with stable weight and low ASVW over four years (OR 3.660; 95% CI 1.402–9.553).

**Conclusions:** Those with high ASVW showed significantly increased risk for diabetes development over four years compared with those who had low ASVW. Weight cycling was significantly associated with increased risk for diabetes.

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## 1. Introduction

The deleterious effects of obesity have been observed, world-wide. According to a World Health Organization report, the prevalence of overweight and obesity was estimated to have reached over 30%, in 2014, worldwide [1]. Because of the marked increase in the prevalence of obesity, an increase in the prevalence of associated diseases, such as diabetes, ischemic heart disease, hyperlipidemia and even cancer, was noted [2,3]. Therefore, several academic associations dedicated to cardiometabolic disease, have declared a war against obesity.

“Yo-yo dieting” or the “yo-yo effect,” also known as “weight cycling,” is defined as the cyclical loss and gain of weight, either intentionally or unintentionally [4,5]. Although various results report the prevalence of weight cycling, it is assumed to range between 20–35% in men and 20–55% in women [6,7]. These wide variations in the results could be attributed to the recruitment of different populations, and the lack of a universally accepted definition of weight cycling [8,9]. For example, in the Nurses’ Health Study (NHS) II that enrolled 46,224 normotensive women, huge variations were noted in the number of times weight was lost (1–3 times over four years) and amount of weight lost (2.25–>4.5 kg) [7]. There are significant differences in the amount of weight lost, and in the definition of weight cycling, in studies performed on different populations. A more serious aspect of this phenomenon is that, because of media exposure to celebrities and models who are thin, even lean and young adolescents attempt to lose weight, thereby exposing themselves to weight cycling [5].

Repeated dieting and weight cycling have been implicated in increasing the risk for eating disorders, other psychological disorders, and multiple morbidities such as obesity, type 2 diabetes, hypertension, cancer, and bone fracture, and increased mortality. However, the effects of weight cycling on health outcomes have been a source of debate [8,9]. The mostly debated effect is the association of weight cycling with type 2 diabetes and cardiovascular morbidity and mortality. In a six-year follow-up study of NHS II, the association between weight cycling and higher rates of type 2 diabetes was no longer significant after adjustment for overall weight status [7]. However, similar results were not noted in a recent study with a nine-year follow-up, in male Finnish smokers [10]. These discrepancies could be attributed to the different study populations, and the methods used for the assessment of weight cycling.

In this study, we calculated the absolute amount of weight fluctuations, over four years, in 4818 non-diabetic participants on whom medical examinations were performed over 5 consecutive years, and analyzed the association between weight cycling and the risk of diabetes development.

## 2. Materials and methods

### 2.1. Study population

This was a retrospective longitudinal study, and a part of the Kangbuk Samsung Health Study, which included participants from a medical health checkup program at the Health Promotion Center of Kangbuk Samsung Hospital, Sungkyunkwan University, Seoul, Korea. The purpose of the medical health checkup program is to promote the health of employees through regular health checkups and to enhance the early detection of diseases. Most of the examinees are employees and their family members, belonging to various industrial companies from around the country. The medical examinations are largely paid for by employers, and a considerable proportion of the examinees undergo examinations annually or biannually.

The initial study population comprised 5230 individuals who participated in the serial medical checkup for 5 consecutive years, from January 2010 to December 2014. Of these participants, 375 were excluded, owing to the presence of diabetes in 2010, and 37 were excluded owing to missing values. The final study population included 4818 participants.

This study was approved by the institutional review board of the Kangbuk Samsung Hospital. The requirement for informed consent was waived because we used unidentifiable data that was routinely collected during the health screening process.

### 2.2. Anthropometric measurement and laboratory assessment

Data on medical history, medication use, and health-related behaviors were collected through a self-administered questionnaire, whereas physical measurements and serum biochemical parameters were obtained by trained staff, during the health examinations. Participants were asked to wear light clothing and no shoes before their body weights were measured to the nearest 0.1 kg, using a digital scale. Height was measured to the nearest 0.1 cm. Body mass index (BMI) was calculated as the weight in kilograms divided by the height in meters squared. Trained nurses measured the sitting blood pressure with standard mercury sphygmomanometers. A “smoker” was defined as a participant who replied “yes” to the question, “Have you smoked more than five packs of cigarettes in your life?” in the self-questionnaire. An alcohol drinker was defined as a participant who consumed alcohol more than twice a week. Regular exercise was defined as the performance of vigorous exercise more than once a week. The presence of family history of diabetes was assessed by the self-questionnaire.

All the participants were examined after an overnight fast. The hexokinase method was used to measure fasting blood sugar (FBS) concentrations (Hitachi Modular D2400; Roche,

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