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(Citation)

Endocrine Journal, 71(3):273-284

(Issue Date)

2024

(Resource Type)

journal article

(Version)

Version of Record

(Rights)

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(URL)

<https://hdl.handle.net/20.500.14094/0100488527>



The humanistic and societal impact of obesity in Japan: a targeted literature review

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Abstract. Obesity is a focus of Japanese public health policy, due to Japanese individuals' high susceptibility to weight-related conditions. In contrast to global definitions, obesity is defined as a body-mass-index (BMI) of ≥ 25 kg/m² in Japan. Despite public efforts, rates of obesity have not decreased over the past decade. To better understand its societal impact, we examined the economic, quality of life (QoL), and complications burden of obesity in Japan. Electronic databases were searched for English and Japanese-language publications from 2005 to December 2020 reporting on adults with obesity in Japan; other diseases were excluded, with no restriction on intervention. Outcomes of interest included costs or resource use, QoL, risk of complications, and other clinical outcomes. We identified 137 studies, including 19 reporting on economic evidence, eight reporting on QoL, and 115 reporting on the relationship between obesity and the risk of complications or mortality. The studies consistently showed that Japanese adults with obesity (BMI ≥ 25 kg/m²) are at increased risk of complications vs. normal weight adults. They also confirmed higher total and medical costs, resource use, and hospitalization costs among adults with obesity vs. normal weight adults. In addition, the studies confirmed a considerable impact of obesity on physical and mental aspects of QoL. Overall, this study found that obesity in Japan is associated with a substantial burden. Japanese people are at risk even with BMI ≥ 25 – <30 kg/m², which are generally considered as pre-obese in other countries.

Key words: Burden, Japan, Obesity

COMPARED WITH OTHER DEVELOPED NATIONS, Japan has a low proportion of the population at body mass index (BMI) ≥ 30 kg/m² (the World Health Organization [WHO] definition of obesity): the age-standardized prevalence of WHO-defined obesity in the United States is seven- and ten-fold greater in men and women, respectively, than in Japan [1]. However, despite a widespread perception that Japan has a healthy-weight population relative to other countries, excess weight is a key focus of Japanese public health policy due to concern about the impact of obesity on Japanese society [2].

When comparing rates of obesity in Japan with those of other nations it is important to consider the ethnicity-specific impact of excess weight: Japanese individuals exhibit the health burden of excess weight at a lower BMI than Caucasian counterparts, and may have greater

fat deposition than a Caucasian at the same BMI [3–5]. A 2006 cross-sectional analysis of ethnic weight differences reported comparable levels of body fat in Caucasian Australian men and Japanese individuals with a 1.5 kg/m²-lower BMI [5]. This is explained by greater abdominal visceral fat deposition in Japanese people than Caucasians [6], which may also be the cause of an observed increased risk of cardiovascular disease and glucose intolerance in Japanese individuals, vs. Caucasians of the same BMI [3]. Around 9–19% of Japanese adults are thought to have diabetes, an obesity-related disease, compared with around 13% of adults in the US, despite the substantially higher obesity and overweight prevalence in the US [7]. Accordingly, the Japan Society for the Study of Obesity (JASSO) defines a BMI of ≥ 25 kg/m² as obese, in contrast to the WHO definition (Table 1).

Unlike key guidelines in the western world, JASSO does not consider obesity a disease in its own right, instead differentiating obesity from “obesity disease” [4, 8]. “Obesity disease” is diagnosed in individuals who require weight reduction for medical reasons, including those with a high probability of developing

Submitted Aug. 11, 2023; Accepted Dec. 6, 2023 as EJ23-0416

Released online in J-STAGE as advance publication Feb. 3, 2024

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Table 1 Japanese and international weight classifications

BMI range (kg/m ²)	JASSO classification	WHO classification
<18.5	Underweight	Underweight
≥18.5 to <25.0	Normal weight	Normal weight
≥25.0 to <30.0	1 st degree obesity	Overweight
≥30.0 to <35.0	2 nd degree obesity	Class I obesity
≥35.0 to <40.0	3 rd degree obesity	Class II obesity
≥40.0	4 th degree obesity	Class III obesity

Abbreviations: BMI, body mass index; JASSO, Japan Society for the Study of Obesity; WHO, World Health Organization.

Source: Ogawa and Miyazaki, 2015[4]

obesity-related conditions [4]. Visceral obesity is recognized as one of the greatest risk factors, and JASSO recommends weight reduction if visceral obesity is confirmed by CT scan [4]. As the JASSO criteria for “obesity disease” clarify, weight loss treatment should be targeted both at individuals with obesity-related comorbidities and those likely to develop them in future [4]. Consequently, it is necessary to identify the patients likely to develop complications, and those who will incur in the greatest quality of life (QoL) decrements and the largest economic burden.

Rates of obesity in Japan have remained unchanged for the past decade and thus the burden of obesity is also likely to remain [2, 7]. Given the well-documented societal impact of obesity globally and the increased risk of obesity-related health complications in Japanese individuals (vs. non-Asians), the societal impact of obesity in Japan could be vast. Despite this, the holistic burden of obesity in Japan is poorly understood. To better delineate this impact, we conducted a targeted literature review to comprehensively describe the economic, QoL, and complications burden of obesity in Japan.

Materials and Methods

Data sources and search strategy

We conducted a search of English and Japanese-language electronic databases, including Embase, MEDLINE, and Cochrane, using pre-defined search strings to identify relevant literature (Supplementary Table 1 and Supplementary Table 2). The search strategy within electronic databases included various terms for “obesity” (e.g., obesity or overweight or high BMI), combined with “cost or resource use or QoL or complication” terms. The search strategy was further restricted to only Japanese population for last 15 years. Hand searching was used to ensure all study types were included, e.g., conference proceedings and reference lists (Supplementary Table 3).

Searches were carried out on 18th December 2020. Citations were screened by abstract and title against pre-defined eligibility criteria, with full publication screening conducted if necessary. Second pass screening was conducted using full publications, and final inclusion or exclusion verified by a second independent reviewer. The review reporting was done based on various guidelines issued by the Cochrane Collaboration and the Centre for Reviews & Dissemination (CRD; York, UK), and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement 2020.

Study eligibility

Study inclusion was limited to adults with obesity (BMI ≥25 kg/m²) in Japan; other diseases were excluded; however, study intervention was not restricted. Outcomes of interest included cost or resource outcomes (studies reporting original cost/resource use data); health-related QoL outcomes (studies reporting recognized QoL tools [e.g., EQ-5D] or utility data); and risk of complications and clinical outcomes, including mortality/life expectancy. Studies published from 2005 to the search date were included. Studies reporting indirect costs were excluded.

Quality assessment and risk of bias

Quality assessment and risk of bias was performed for the studies included in the review. Methodological limitations of cost of illness (COI)/economic burden studies were assessed with a checklist developed on a model described by Drummond *et al.* 2005 and adapted to COI by Molinier *et al.* 2008 [9]. Studies included in the humanistic and complication review were assessed using the Effective Public Health Practice Project (EPHPP) quality assessment tool [10].

Results

Studies identified

In total, 10,505 citations were identified during electronic database searches; 2,789 were removed as duplicates and 7,621 excluded during first or second pass screening (Fig. 1). Of the 137 publications identified (Supplementary Table 4) from electronic databases and hand searching, 19 related to economic evidence for the impact of obesity, eight studies reported on QoL impact, and 115 studies reported on the relationship between obesity and the risk of complications or mortality (only 70 studies on complication risk are described here, due to substantial heterogeneity in the publications identified). Economic and QoL studies were mostly observational cohort studies from various regions of Japan; populations of QoL studies were largely heterogenous

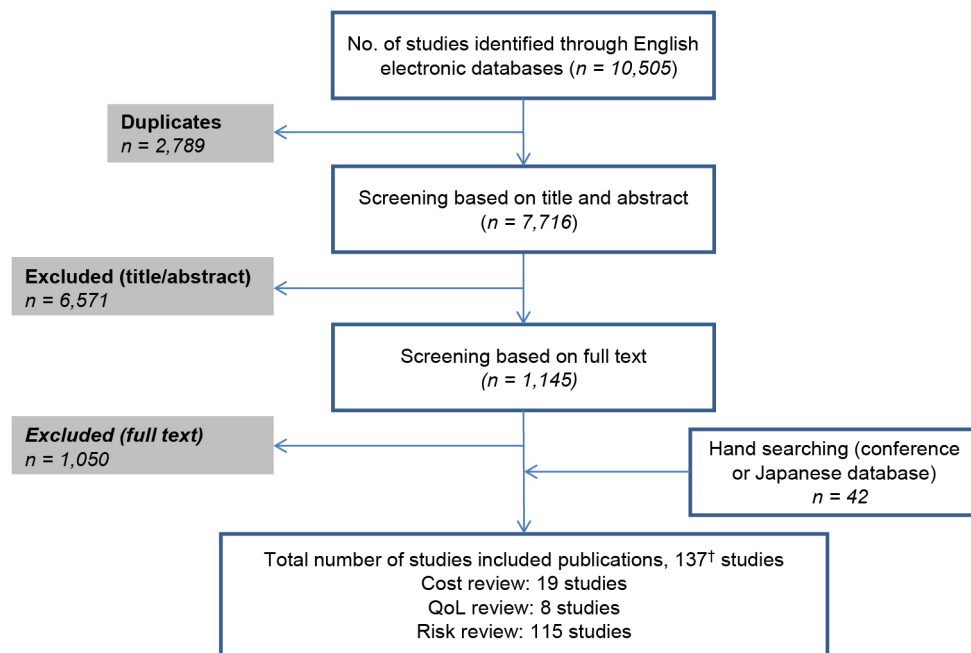


Fig. 1 PRISMA flow diagram for the literature review

†Studies may be included in more than one category; therefore, the three categories do not sum to the total.

Abbreviations: PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; QoL, quality of life.

and different QoL instruments were often used. Among studies reporting on complications and/or mortality risks, the majority reported on the relationship between obesity and mortality risk.

All weight classifications described follow JASSO BMI guidelines, irrespective of wording in the original publication (*i.e.*, BMI ≥ 25 – <30 kg/m² will be considered obese, not overweight).

Economic burden of obesity

Evidence on the economic burden of obesity in Japan was available but lacking for patients with very high BMI (≥ 35 kg/m²). Data in six publications were derived from the Ohsaki National Health Insurance (NHI) beneficiaries cohort study.

Economic burden by BMI or weight category

Overall healthcare costs

Across the literature reviewed, obesity was reported to increase healthcare costs compared with normal weight. Adults with obesity were reported to have higher lifetime medical expenditure [11], and significantly higher annual medical expenditures *vs.* individuals without obesity [12]. Two studies also reported significantly higher monthly medical costs in individuals with obesity than in individuals with normal weight ($p < 0.05$) [13, 14]. Obesity was associated with 8.2% growth rate in total medical expenditures *vs.* individuals of normal weight in one study [15], and with significantly higher total medi-

cal costs *vs.* normal weight in another study; excess monthly medical costs attributable to obesity for entire population cohort ($N = 4,502$) were estimated at EUR 19,908 (originally calculated in JPY and then converted to EUR on the currency exchange in 2006) per month and represented 3.1% of entire total medical costs for people with obesity [16]. Obesity was reported to impose 9.6% of medical costs (population attributable fraction) in a large cohort study of insurance beneficiaries [13].

One study reported total per-person monthly medical costs of USD 220.10 (originally calculated in JPY and then converted to USD, USD 1 = 120 JPY) in patients with BMI ≥ 30 kg/m², USD 40 higher than individuals of normal weight [17]. Another analysis of the same cohort reported a U-shaped association with BMI for direct monthly medical costs, with highest mean costs in individuals with BMI ≥ 30 kg/m² (18.2% higher mean costs than normal weight) and lowest costs in individuals with BMI 21.0–22.9 kg/m² [18]. However, a study analyzing total medical expenses in the elderly found no U-shaped association, reporting similar costs between individuals with normal weight and underweight, but much higher costs in individuals with obesity (JPY 11,861–14,230 for individuals with normal weight/underweight, *vs.* JPY 18,071–18,352 for obesity) [19].

Additional risk factors were also reported to increase the economic burden of obesity: lack of exercise and/or smoking combined with obesity resulted in increased

medical expenditure growth rate vs. a person without these lifestyle risk factors [15], and health insurance claims were higher with presence of abdominal obesity (AO) vs. no AO [20].

One study reported on medication costs: the overall cost of medications was significantly higher in individuals with type 2 diabetes (T2D) and obesity vs. individuals of normal weight ($p < 0.001$) [12].

Hospitalization and inpatient costs

Hospitalization costs were reported to be significantly higher for obesity than for normal weight and underweight in one study ($p = 0.03$) [12]. Another study found no significant difference in anesthesia duration or median length of stay between normal weight and obesity [21].

Outpatient costs

Studies reported a greater number of outpatient visits [12] and significantly higher outpatient costs [14] for individuals with obesity vs. those with normal weight. A ≥ 10 kg weight gain was also associated with increased outpatient costs vs. no weight gain [22].

Economic burden of obesity by comorbidities

Overall healthcare costs

Overall healthcare costs could be expected to increase in the presence of health conditions alongside obesity, and this was observed in the literature. Direct medical costs were reported to increase if one or more obesity-dependent cardiovascular (CV) risk factors were present [23], and they were noted to be higher in individuals with obesity plus diabetes, ischemic heart disease, or renal failure compared with individuals with normal weight and such comorbidities [24]. Whereas obesity alone increased medical expenditure by 2.4% vs. normal weight, obesity associated with one or 2–3 CV risk factors increased costs by 1.8% and 2.9%, respectively, vs. normal weight without risk factors [25]. The greatest expenditure increase (13.1%) was observed in normal weight individuals with 1 CV risk factor, but this likely resulted from the low prevalence of obesity in Japan relative to normal weight.

Total medical expenditure was significantly higher for obesity with either hypertension, or hypercholesterolemia, vs. normal weight, but not significantly different for diabetes despite a large difference in expenditure for obesity vs. normal weight [25]. Health expenditure was also higher in patients with AO (vs. without AO) for diabetes, high low-density lipoprotein cholesterol (LDL-C), low high-density lipoprotein cholesterol (HDL-C), or hypertension [20]. Costs for hyperglycemia, hypertension, or dyslipidemia medications were higher in patients with obesity than those with normal weight [12].

Hospitalization and inpatient costs

One study reported significantly higher annual hospi-

talization costs in patients with T2D and obesity vs. individuals with T2D and normal weight (JPY 602,079 vs. JPY 307,119; $p = 0.03$) [12]. Inpatient costs were also higher for obesity combined with comorbidities (hypertension/hyperglycemia/hypertension and hyperglycemia) than for obesity alone [14].

The 4-year hospitalization incidence in one study showed significant variation among ‘healthy’ individuals (0–1 metabolic comorbidities), with higher incidence for obesity ($\geq 15.8\%$) than normal weight (14.1%), and highest incidence for BMI ≥ 30 kg/m² (20.0%; $p < 0.001$). Although incidences were higher for ‘unhealthy’ individuals (≥ 2 metabolic comorbidities) than for ‘healthy’, the increase was greater for normal or underweight than for obesity, suggesting a limited impact of “obesity disease” [26].

Outpatient costs

Annual outpatient services costs were reported to be significantly higher in individuals with T2D and obesity compared with individuals of normal weight with T2D (JPY 100,650 vs. JPY 92,490; $p = 0.001$) [12]. Obesity combined with comorbidities (hypertension/hyperglycemia/hypertension and hyperglycemia) imposed higher direct outpatient costs than obesity alone [14].

Economic burden of obesity by age and gender

Compared with normal weight, a slightly higher lifetime medical expenditure increase for BMI ≥ 30 kg/m² was reported in women than in men (+22% and +15% vs. normal weight, respectively), but both genders had similar increase for BMI 25–29.9 kg/m² (+15% and +17%, respectively) [11]. One study reported comparable costs in men with CV risk factors irrespective of obesity, whereas obesity was associated with higher medical costs in women with CV risk factors compared with those without obesity [23]. However, two other studies reported comparable medical costs between men and women with obesity or weight gain [19].

In a large insurance database study, monthly medical costs were significantly higher for individuals with obesity than for those of normal weight for all ages and genders ($p < 0.001$) [13]. However, the impact of obesity was greater in those aged 40–59 years (population attributable fraction: 11.63–12.76) than those aged 60–69 years (population attributable fraction: 6.55–7.80) for both genders ($p < 0.005$) [13]. A study of weight gain during adulthood reported greater costs in individuals with ≥ 10 kg weight gain than in those without weight gain, with annual total costs and outpatient costs increasing by age: at age 40–44 years, total costs were JPY 2,111–3,996, however at age 70–74 years this rose to JPY 24,759–25,505 for those who gained weight, vs. JPY 19,440–19,936 for those who maintained their weight [22].

Quality of life impact of obesity

The included studies used different QoL instruments, resulting in heterogenous evidence, but provide a broad picture of QoL in individuals with obesity. Two studies used SF-8, three used SF-36, one used WHO QOL-26, and one used the Asthma Quality of Life Questionnaire (AQLQ). The last study used a survey to assess sleep quality. Data are lacking for very high BMI groups (≥ 35 kg/m²), despite a potentially very large QoL impact of obesity in these patients.

Physical QoL findings were reported using the SF-8 and SF-36 surveys [27-31]. In one study, significantly worse SF-36 physical functioning scores were reported for women with obesity vs. normal weight ($p = 0.043$), but comparable scores for men with and without obesity [28]. Likewise, another study reporting SF-36 scores found an association between BMI, waist wall, and trunk fat and decrements to the body function domain in women ($p < 0.05$ for all), but no significant associations in men [30]. Obesity was associated with reduced physical QoL (vs. normal weight) in one SF-8 study, with decrements for all physical domains except general health perceptions for those with BMI ≥ 25 – <30 kg/m², and the greatest QoL impairments for individuals with BMI ≥ 30 kg/m². The impact of obesity on the physical component summary (PCS) score was greatest in women, but the presence of concurrent chronic disease did not have a significant impact on PCS [31]. The presence of metabolic syndrome (vs. no metabolic syndrome) was associated with significant reductions in physical QoL in people aged ≥ 65 years ($p = 0.022$), but not in those aged <65 years in another study using SF-8 scores [32]. In an internet-based survey of Japanese women with obesity, high levels of body dissatisfaction were associated with lower physical and overall WHO QOL-26 scores [33].

The impact of obesity on mental, social and emotional QoL was reported in four studies [28, 31-33]. Male participants showed a significant association between obesity and mental component impairments (vs. normal weight) in one SF-36 survey, with decrements in the social functioning ($p = 0.045$), and role emotional ($p = 0.017$) domains; however, no significant decrements were reported in women [28]. Obesity was not associated with significantly reduced mental QoL in a study reporting SF-8 findings; however, those with BMI ≥ 30 kg/m² reported a lower mental component summary (MCS) score than those with normal weight or BMI ≥ 25 – <30 kg/m². The presence of chronic disease significantly impaired MCS [31]. Metabolic syndrome vs. no metabolic syndrome was associated with a significantly higher proportion of elderly patients (aged ≥ 65 years) experiencing mental QoL reductions based on SF-8 ($p = 0.01$). No association was found in younger

patients (aged <65 years) [32]. Body dissatisfaction in women with obesity was associated with poor social and psychological WHO QOL-26 scores, in an internet-based survey [33].

Asthma-related QoL impairments were associated with four indices of obesity in a study across 30 health-care facilities: abdominal visceral fat ($p < 0.001$), BMI ($p = 0.007$), waist circumference ($p = 0.009$), and abdominal subcutaneous fat ($p = 0.011$) [34]. However, when stratified by gender, only abdominal visceral fat was associated with poor QoL in men, whereas all four indices were associated with poor asthma-related QoL in women.

A study in individuals aged ≥ 80 years reported significantly worse sleep quality scores in those with obesity vs. normal weight ($p < 0.05$), and a significant negative correlation between sleep efficiency and BMI [35].

Risk of mortality and complications with obesity

Evidence on the risk of mortality and complications with obesity was collected for a range of patient populations and provides a broad insight into risk for different BMI groups (BMI ≥ 25.0 – <27.0 kg/m², ≥ 27.0 – <30.0 kg/m², and ≥ 30.0 kg/m²). However, few data were available for very high BMI groups (BMI ≥ 35 kg/m²).

Eight studies reported on the relationship between obesity and all-cause mortality (Table 2). Obesity or gained weight had no association with mortality risk in three studies [16, 36, 37], increased the risk in one study [38], and decreased the risk in two studies [39, 40]. The two remaining studies reported reduced risk at a low BMI (≥ 25.0 – <27.0 kg/m² and ≥ 25.0 – <30.0 kg/m²) but no or increased risk at a higher BMI (≥ 27.0 kg/m² and ≥ 30.0 kg/m², respectively) [41, 42]. However, when analyzing mortality by gender, six out of nine studies found an increased risk in all-cause mortality in at least one BMI category for women, and one study found an increased risk for men [11, 17, 43-49]. Only one study found a decrease in mortality risk, observed in men with BMI ≥ 25.0 – <27.0 kg/m² (Table 3) [11]. The observed trend suggests increasing risk as BMI increases (increased risk most commonly reported for BMI ≥ 30 kg/m²) and greater risk in women than in men. Six studies reported that obesity appeared to confer an increased all-cause mortality risk in people with comorbidities vs. normal weight (Table 4) [50-55]. Obesity was also found to increase the risk of cause-specific mortality across several publications reporting risk of death from cardiac causes, CV disease (CVD), total CVD, and coronary heart disease (Supplementary Table 5) [53, 56], but was not associated with risk of stroke or hemorrhage death [49, 55-57].

One study reported the impact of obesity on life

Table 2 All-cause mortality risk – relationship with weight category vs. reference weight

Study	Population	Reference	Weight/BMI descriptor		
			≥25.0 to <27.0 kg/m ²	≥27.0 to <30.0 kg/m ²	≥30.0 kg/m ²
Nakamura 2007 [14]	Adults aged 40 to 69 years	≥18.5 to <25.0 kg/m ²	<i>No association</i>		
Yano 2013 [34]	Adults living in communities (mean age: 54 years)	≥21.1 to <25.0 kg/m ²	<i>No association</i>		
Nakanishi 2006 [36]	A-bomb victims	≥18.5 to <22.0 kg/m ²	<i>Risk increase</i>		
Takata 2007 [37]	Subjects aged ≥80 years	≥18.5 to ≤24.9 kg/m ²	<i>Risk decrease</i>		
Yamazaki 2017 [39]	Adults aged 65 to 84 years	≥23.0 to ≤24.9 kg/m ²	<i>Risk decrease</i>	<i>No association</i>	<i>No association</i>
Shimazu 2009 [40]	Adults aged 40 to 79 years	≥18.5 to ≤24.9 kg/m ²	<i>Risk decrease</i>	<i>Risk decrease</i>	<i>Risk increase</i>
Stable overweight					
Murayama 2015 [38]	Adults aged ≥60 years	Mid-normal decreasing weight	<i>Risk decrease</i>		
Gained weight					
Nishida 2019 [35]	Adults aged ≥65 years	Stable weight	<i>No association</i>		

Abbreviation: BMI, body mass index.

Table 3 All-cause mortality – relationship with weight category vs. reference weight, by gender

Study	Population	Reference	BMI					
			≥25.0 to <27.0 kg/m ²		≥27.0 to <30.0 kg/m ²		≥30.0 kg/m ²	
			Female	Male	Female	Male	Female	Male
Murayama 2020 [46]	Japanese adults aged 60 years or more	23.0 to 24.9 kg/m ²	<i>No association</i>	<i>No association</i>	<i>No association</i>	<i>No association</i>	—	—
Nakade 2015 [47]	Subjects aged >65 years	23.0 to 24.9 kg/m ²	<i>No association</i>	<i>No association</i>	—	—	—	—
Hayashi 2005 [41]	Residents aged 40 to 69 years	22.0 to 24.9 kg/m ²	<i>No association</i>	<i>No association</i>	<i>Risk increase</i>	<i>No association</i>	—	—
Kuriyama 2006 [15]	Residents aged 40 to 64 years	23.0 to 24.9 kg/m ²	—	—	—	—	<i>Risk increase</i>	<i>No association</i>
Nagai 2012 [9]	NHI beneficiaries aged 40 to 79 years	18.5 to 24.9 kg/m ²	<i>No association</i>	<i>Risk decrease</i>	—	—	<i>No association</i>	<i>No association</i>
Matsuo 2008 [42]	General population; aged 40 to 59 years	23.0 to 24.9 kg/m ²	<i>No association</i>	<i>No association</i>	<i>Risk increase</i>	<i>No association</i>	<i>Risk increase</i>	<i>No association</i>
Tamakoshi 2010 [43]	Healthy subjects aged 65 to 79 years	20.0 to 22.9 kg/m ²	<i>No association</i>	<i>No association</i>	<i>No association</i>	<i>No association</i>	<i>Risk increase</i>	<i>No association</i>
Tanaka 2005 [44]	General population; aged 40 to 59 years	23.0 to 24.9 kg/m ²	<i>No association</i>	<i>No association</i>	<i>No association</i>	<i>Risk increase</i>	<i>Risk increase</i>	<i>Risk increase</i>
Nagai 2010 [45]	NHI beneficiaries aged 40 to 79 years	23.0 to 24.9 kg/m ²	<i>No association</i>	<i>No association</i>	<i>No association</i>	<i>No association</i>	<i>Risk increase</i>	<i>No association</i>

Abbreviations: BMI, body mass index; NHI, Ohsaki National Health Insurance.

Table 4 Mortality outcomes – relationship with weight category vs. reference weight across different comorbidities

Study	Population	Outcome	Reference	BMI	
				≥25 to <30.0 kg/m ²	≥30 kg/m ²
Yanagisawa 2016 [48]	Outpatients clinic AF patients aged ≥70 years old	Predictors of all-cause death by BMI change (per 1 kg/m ²)	BMI change (per 1 kg/m ²)	<i>Risk decrease</i>	—
Shiraishi 2007 [49]	Patients with AMI (mean age: 58 years)	BMI as mortality predictor	≥18.5 to <25.0 kg/m ²	<i>No association</i>	—
Matsushita 2017 [50]	Patients with AHF admitted to the ICU (mean age: 63 years)	Relationship between BMI and death within 910 days	≥16.0 to <25.0 kg/m ²	—	<i>No association</i>
Yoshihisa 2019 [51]	Hospitalized patients with AHFSs (mean age: 73 years)	All-cause mortality by BMI	<25 kg/m ²	<i>Risk increase</i>	—
Yamazaki 2020 [52]	Patients with diabetes (mean age: 54 years)	All-cause mortality by BMI	≥23.0 to ≤24.9 kg/m ²	<i>No association</i>	<i>Risk increase</i>
	Patients with HF (mean age: 68 years)	All-cause mortality by BMI	≥23.0 to ≤24.9 kg/m ²	<i>No association</i>	<i>Risk increase</i>
Nochioka 2010 [53]	Patients with LVEF ≥50%	All-cause mortality by BMI	≥23.0 to ≤24.9 kg/m ²	<i>No association</i>	<i>Risk increase</i>
	Patients with LVEF <50%	All-cause mortality by BMI	≥23.0 to ≤24.9 kg/m ²	<i>Risk increase</i>	<i>Risk increase</i>

Abbreviations: AF, atrial fibrillation; AHF, acute heart failure; AHFSs, Acute Heart Failure Syndromes; AMI, acute myocardial infarction; BMI, body mass index; CHD: coronary heart disease; HF, heart failure; ICU, intensive care unit; LVEF, left ventricular ejection fraction.

expectancy: at age 40 years, those with BMI 25–29.9 kg/m² had a similar life expectancy to normal weight individuals (44.3 and 43.0 years, respectively, in men; 52.6 and 52.3 years, respectively, in women; Supplementary Fig. 1) [11]. Conversely, life expectancy was slightly lower for both men and women with BMI ≥30 kg/m², who lost an average 2–3 years of life vs. normal weight (41.4 and 49.2 years, respectively) [11].

Multiple studies reported on the risk of complications with obesity [29, 54, 55, 57–100]. Generally, obesity was found to increase the risk of CVD- and coronary artery disease (CAD)-related complications vs. individuals without obesity (Supplementary Table 6 and Supplementary Table 7), and to increase the risk of stroke, with a trend towards greatest stroke risk in women and those with BMI ≥30 kg/m² (Supplementary Table 8) [57, 58, 64–76]. All studies analyzing the risk of diabetes found that obesity was associated with increased risk, irrespective of age (Supplementary Table 9) [54, 78–85, 101]; three studies found a higher risk in women than in men [80, 81, 83], and four studies reported a decrease in diabetes risk with age [79, 81, 85, 101]. Obesity was reported to increase the risk of hypertension in all studies that investigated this, regardless of gender (Supplementary Table 10) [82, 86–97]. Obesity was also associated with a risk of developing dyslipidemia (Supplementary Table 11) [79, 91, 98–100].

Discussion

This literature review confirms that obesity in Japan is associated with increased costs, a QoL burden, and increased risk of mortality and complications compared with normal weight and provides a descriptive overview of the impact of obesity on Japanese society. The impact of obesity is especially high in patients with BMI ≥30 kg/m² and monitoring these individuals for development of obesity-related conditions or reduced QoL should be a priority for healthcare professionals.

The reviewed economic literature indicated that obesity in Japan is associated with substantial economic burden, which was generally reported to increase as BMI increased when the impact by BMI group was investigated. This financial burden may have a large effect on healthcare resource use across Japan; although this affirms the value of public health policy intended to tackle obesity, stable obesity prevalence over the past 10 years suggests the economic impact is unlikely to reduce [2, 7].

Reviewed literature showed that the physical and mental health-related QoL burden of obesity in Japan may also be substantial, especially in elderly or female individuals. Any further effect of these impacts was not reported by the assessed literature, meaning it is unclear how detrimental these are to work and leisure for individuals with obesity.

Japanese individuals with obesity (BMI ≥25 kg/m²)

are at enhanced risk of complications vs. normal weight individuals as the risk is not restricted to those with BMI ≥ 30 kg/m² [3]. These complications are likely a substantial contributor to the economic and QoL burdens reported across the identified literature and may contribute to mortality in some individuals. Some of the identified studies reported a decreased risk of complications in elderly people with mild obesity (BMI ≥ 25.0 – <27.0 kg/m²). This “obesity paradox” (*i.e.*, a protective effect conferred by obesity [102]) was observed for mortality in some studies, but not all: despite an all-cause mortality risk decrease with obesity in five of the seven studies that examined risk by BMI group, this trend was reversed in studies that stratified by gender or comorbidities. Obesity also generally increased the risk of cardiovascular mortality. Any protective effect of obesity appears to be restricted to men and to those with lower BMIs, with no benefit to women. Moreover, individuals with existing comorbidities, who are likely to have “obesity disease”, are generally at increased risk of all-cause mortality [3].

The limitations of this review include the heterogeneity in methodological approaches, population, and reported outcomes in the included studies. Moreover, perhaps due to the small number of individuals with BMI ≥ 35 kg/m² across Japan, no data on the impact on very high BMI groups was found, despite the potential for a much higher disease burden in these individuals.

Overall, this study found that obesity in Japanese people is associated with substantial economic and QoL burden and an increased risk of complications when compared with normal weight individuals. Japanese people are at risk even with BMI ≥ 25 – <30 kg/m², which

are generally considered as pre-obese in other countries.

Acknowledgements

Targeted literature research and medical writing support were provided by Clarivate Consulting Services, London, UK. This study was funded by Novo Nordisk Pharma LTD.

Disclosure

Funding

This work was funded by Novo Nordisk Pharma LTD. Previous research projects have been funded by Noster, Nippon Boehringer Ingelheim Co., Ltd., Boehringer Ingelheim Pharma GmbH & Co. KG, Eli Lilly Japan K.K., Novo Nordisk Pharma LTD., Abbott Japan, Abbott Diabetes Care UK Ltd, Sumitomo Dainippon Pharma Co., Ltd., and Teijin Pharma.

Prof. Ogawa has received lecturing fees from Sumitomo Dainippon Pharma Co., Ltd., Nippon Boehringer Ingelheim Co., Ltd., Takeda Pharmaceutical Co. Ltd., Abbott Japan, and Novo Nordisk Pharma LTD and has been awarded scholarships and research incentives by Kowa Company, Ltd., Novo Nordisk Pharma LTD., Astellas Pharma Inc., Sumitomo Dainippon Pharma Co., Ltd., ONO PHARMACEUTICAL CO., LTD., Takeda Pharmaceutical Co. Ltd., Abbott Japan, Novartis Pharma K.K., DAIICHI SANKYO CO., LTD., Eli Lilly Japan K.K., Mitsubishi Tanabe Pharma Corporation, Nippon Boehringer Ingelheim Co., Ltd., and Teijin Pharma.

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