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ORIGINAL CONTRIBUTIONS

Influence of Asian Ethnicities on Short- and Mid-term Outcomes Following Laparoscopic Sleeve Gastrectomy

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Abstract

Purpose Prevalence of obesity in Asia has been on the increasing trend, with corresponding increase in utilisation of bariatric surgery. The objective of this study was to examine differences in weight loss outcomes following bariatric surgery between Asian ethnicities.

Materials and Methods A retrospective database review was conducted of patients undergoing primary laparoscopic sleeve gastrectomy between 2009 and 2013 in 14 centres from Singapore, Malaysia, Taiwan, Hong Kong, Japan, Korea, India, Australia, Switzerland, and the USA. All patients with available follow-up data at 12 months and 36 months post-surgery were included in this study. Outcome measures used were percentage excess weight loss (%EWL) and percentage total weight loss (%TWL). Differences in outcomes between ethnicities were analysed after adjusting for age, gender, baseline body mass index (BMI), and presence of diabetes.

Results The study population ($n = 2150$) consisted of 1122 Chinese, 187 Malays, 309 Indians, 67 Japanese, 259 Koreans, and 206 Caucasians. 67.1% were female and 32.9% were male. Mean age was 37.1 ± 11.2 years. Mean pre-operative BMI was 40.7 ± 8.1 kg/m^2. With the Caucasian population as reference, Japanese had the best %TWL (3.90, 95% CI 1.16–6.63, $p < 0.05$) and

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%EWL (18.55, 95% CI 10.33–26.77, $p < 0.05$) while the Malays had the worst outcomes. Both Chinese and Koreans had better %EWL but worse %TWL as compared to Caucasians and there were no significant differences with the Indian study group.
Conclusion There are differences in weight loss outcomes following bariatric surgery between Asian ethnicities.

Keywords Bariatric surgery · Asian ethnicity · Obesity · Sleeve gastrectomy · Weight loss outcomes

Introduction

Global prevalence of obesity has been on the increasing trend, more than doubling since the 1980s [1]. It is now recognised as a health crisis given its negative impact on life expectancy by way of increasing risk of adverse chronic health conditions including cardiovascular disease, insulin resistance, diabetes, sleep apnoea, musculoskeletal disorders, and cancer [2–5]. Additionally, it also diminishes quality of life and increases economic burden to the workplace and to the healthcare system [6].

In Singapore, 4 out of 10 adults are overweight with body mass index (BMI) ≥ 25 kg/m^2 and there has also been an increase in the prevalence of obesity (BMI ≥ 30 kg/m^2 based on the World Health Organization definition) from 6.9 in 2004 to 10.8% in 2010. Like other developed countries [7–10], ethnic disparities in the prevalence of obesity and its sequelae are present and are widening in Singapore. Across ethnic groups, Malays experienced both the highest prevalence of obesity and the steepest increase in obesity prevalence from 2004 to 2010 (from 19.1% in 2004 to 24% in 2010), relative to Indians (from 13.4% in 2004 to 16.9% in 2010) and Chinese (from 4.2% in 2004 to 7.9% in 2010) [11, 12]. The latest data from the National Registry of Diseases Office (NRDO), Singapore, also show that the local Malay population are at the highest risk of myocardial infarction, end-stage renal failure, and stroke [13–15].

Since 1991, bariatric surgery has been indicated for patients with BMI > 40 kg/m^2 and BMI ≥ 35 kg/m^2 with comorbid conditions, demonstrating not only longer periods of sustained weight loss comparative to conventional methods [16], but also benefits in the remission of diabetes and control of cardiovascular risk factors [17, 18].

Several studies, majority of which were conducted in the USA and Europe, have concluded ethnic differences in weight loss outcomes after bariatric surgery [19–25]. Etiologic factors of such differences are not yet well understood, but have been postulated to be multifactorial, contributed by cultural, genetic, biological, and socioeconomic factors. However, little is currently known with regard to the differences in outcomes after bariatric surgery between Asian ethnicities. This multi-centre retrospective study aims to compare 3-year weight loss outcomes between Asian ethnicities against Caucasians following laparoscopic sleeve gastrectomy.

Patients and Methods

A retrospective database review was conducted of patients undergoing primary laparoscopic sleeve gastrectomy between 2009 and 2013 in 14 specialised centres from Singapore, Malaysia, Taiwan, Hong Kong, Japan, Korea, India, Australia, Switzerland, and the USA ($n = 2150$). All patients met the 2005 National Institute of Health Consensus requirements for bariatric surgery, which include a BMI > 40 kg/m^2 or a BMI ≥ 35 kg/m^2 with associated comorbidity [26]. All patients of Chinese, Korean, Japanese, Malay, Indian, or Caucasian ethnicity with available follow-up data at 12 months and 36 months post-surgery were included in this study. Inclusion of patients based on these ethnic groups was dependent on patient registration ethnicity at each centre. Patients who received revision procedures were excluded from the final analysis.

Data collected at each centre included sex, age, ethnicity, height, weight (at the time of surgery and follow-up), comorbidities, and follow-up duration. Outcome measures of bariatric surgery used in this study were percentage of excess weight loss (%EWL) and percentage total weight loss (%TWL). %EWL was defined as (weight loss/excess weight above BMI ≥ 25 kg/m^2 × 100). %TWL was defined as (weight loss/pre-operative weight × 100).

Baseline data was expressed as frequencies and percentages for categorical characteristics, and the differences in distributions across the different ethnic groups were compared using the χ^2 test. The means and standard deviations were used to summarise continuous variables and compared using the one-way analysis of variance (ANOVA) test.

The linear mixed effect model was implemented to examine the association between %EWL and %TWL with bariatric outcomes. This accounted for the possible intra-subject correlation in %EWL and %TWL measurements at 12 and 36 months follow-up. Asian ethnicity which included Chinese, Korean, Japanese, Malay, and Indian was regarded as the key exposure of interest, with Caucasian as reference group. In the multivariable analysis, variables that were significant at the 5% level in the bivariate analysis were considered for adjustment, and these included age, gender, baseline BMI, and preop T2DM.

Additional analyses were conducted to compare %EWL and %TWL outcomes within the same ethnic group, namely Chinese, Malays, and Indians, from different countries. All statistical evaluations were carried out assuming a two-sided test at the 5% level of significance using STATA version 14.

Results

The study population consisted of 1122 Chinese, 187 Malays, 309 Indians, 67 Japanese, 259 Koreans, and 206 Caucasians (Table 1). Their mean age was 37.1 ± 11.2 years. Chinese and Korean patients tended to be operated on at a younger age ($p < 0.001$). Two-thirds of the patients were female, with a similar percentage across ethnic groups except for the Indians and Japanese who tended to have a higher proportion of male patients ($p < 0.001$). All ethnic groups had similar height distribution, with a mean of 164.7 ± 8.8 cm. Mean baseline BMI was 40.7 ± 8.1 kg/m^2 and this was highest in Caucasians followed by Indians, Malays, Japanese, Koreans, and finally Chinese. A total of 18.3% of patients had type 2 DM. The Japanese had the highest proportion of patients with type 2 DM (35.8%).

In terms of compliance, a total of 22.3% and 42.5% of patients were lost to follow-up at 1 year and 3 years respectively. No Japanese patients were lost to follow-up. Among the other ethnic groups, Indians and Koreans had better follow-up rates compared to Caucasians, Malays, and Chinese ($p < 0.001$).

Impact of Ethnicity

%TWL varied significantly ($p < 0.001$) among the different ethnic groups in the univariate analysis, with Japanese demonstrating the best weight loss outcome as compared to Caucasians (mean difference 3.90, 95% CI 1.16 to 6.63). Chinese and Koreans had similar mean %TWL, which were lower than the Caucasians, while the Malays observed the smallest mean difference of − 4.42 (95% CI − 6.30 to − 2.54). There was no evidence of difference in mean %TWL between Indian and Caucasian in univariate analysis (Table 2). Similar patterns of variation were noted and remained significant across ethnic groups after adjusting for age, gender, initial BMI, and the effect of time.

Of interest, in the analysis of %EWL, less favourable outcomes in %TWL among Chinese and Koreans are no longer seen. Instead, the two ethnic groups now demonstrated higher mean %EWL as compared to Caucasians (both $p < 0.001$) with a magnitude similar to the Japanese (Table 3). These observations remained significant (all $p < 0.05$) after adjusting for age, gender, initial BMI, pre-operative T2DM, and the effect of time. While the mean %EWL of the Japanese remained consistently higher than the Caucasians (mean difference 17.48, 95% CI 9.74 to 25.22), the magnitude of difference among Chinese (mean difference 10.47, 95% CI 4.71 to 16.23) and Koreans (mean difference 9.13, 95% CI 3.10 to 15.15) have diminished. Poorer outcomes in Malay patients continue to be demonstrated in the adjusted analysis ($p = 0.013$). The difference in mean %EWL between Indian and Caucasian was however not significant.

Impact of Age, Gender, Pre-operative BMI, and T2DM

Apart from ethnicity, our results also found age to be a predictor of weight loss outcomes. The mean %TWL and mean %EWL were significantly reduced with each increasing decade of life as compared to younger patients aged ≤ 30 years ($p < 0.001$). The result remained significant after adjusting for other potential confounders (Tables 2 and 3).

Conversely, males and patients with pre-operative BMI ≥ 50 demonstrated significantly higher mean %TWL but lower

Table 1 Patient demographics and baseline clinical characteristics

Characteristics	Overall ($n = 2150$)	Chinese ($n = 1122$)	Malay ($n = 187$)	Indian ($n = 309$)	Japanese ($n = 67$)	Korean ($n = 259$)	Caucasian ($n = 206$)	p value
Mean age, years (SD)	37.1 (11.2)	35.0 (10.4)	40.7 (10.5)	40.2 (11.3)	41.1 (10.4)	32.8 (9.8)	45.0 (11.6)	< 0.001
Gender (%)								< 0.001
Male	707 (32.9)	342 (30.5)	63 (33.7)	135 (43.7)	35 (52.2)	84 (32.4)	48 (23.3)	
Female	1443 (67.1)	780 (69.5)	124 (66.3)	174 (56.3)	32 (47.8)	175 (67.6)	158 (76.7)	
Mean height, cm (SD)	164.7 (8.8)	164.3 (8.4)	162.1 (8.8)	164.7 (9.4)	165.8 (10.4)	166.6 (9.0)	166.9 (9.0)	< 0.001
Mean preop weight, kg (SD)	111.1 (26.8)	104.2 (23.1)	115.6 (29.1)	121.6 (29.0)	120.2 (31.5)	109.2 (24.9)	128.1 (26.5)	< 0.001
Mean BMI, kg/m^2 (SD)	40.7 (8.1)	38.4 (6.6)	43.8 (8.9)	44.6 (9.0)	43.4 (8.8)	39.1 (7.1)	45.9 (8.2)	< 0.001
Type 2 diabetes mellitus (n, %)	394 (18.3)	154 (13.7)	31 (16.6)	72 (23.3)	24 (35.8)	54 (20.9)	59 (28.6)	0.001
Lost to follow-up at 1 year	480 (22.3)	373 (33.2)	25 (13.4)	28 (9.1)	0 (0)	11 (4.3)	43 (20.9)	< 0.001
Lost to follow-up at 3 years	914 (42.5)	688 (61.3)	65 (34.8)	58 (18.8)	0 (0)	50 (19.3)	53 (25.7)	< 0.001

Table 2 Univariate association and repeated measures analysis between repeated %TWL and baseline demographic and clinical characteristics

Univariate association				Repeated measures analysis		
Variables	Coefficient	95% CI	*p* value	Coefficient	95% CI	*p* value
Age (years)			< 0.001			
≤ 30	Ref	–	–	Ref	–	–
31–40	− 2.49	− 3.88 to − 1.11	< 0.001	− 3.14	− 4.51 to − 1.76	< 0.001
41–50	− 4.70	− 6.17 to − 3.24	< 0.001	− 5.44	− 6.92 to − 3.96	< 0.001
> 50	− 5.77	− 7.32 to − 4.22	< 0.001	− 6.92	− 8.47 to − 5.37	< 0.001
Gender						
Female	Ref	–	–	Ref	–	–
Male	2.80	1.65 to 3.95	< 0.001	2.22	1.11 to 3.33	< 0.001
Ethnicity			< 0.001			< 0.001
Caucasian	Ref	–	–	Ref	–	–
Chinese	− 1.89	− 3.56 to − 0.23	0.026	− 3.26	− 4.93 to − 1.59	< 0.001
Malay	− 4.42	− 6.30 to − 2.54	< 0.001	− 5.12	− 7.00 to − 3.23	< 0.001
Indian	− 1.70	− 3.56 to 0.15	0.072	− 3.19	− 4.98 to − 1.40	< 0.001
Japanese	3.90	1.16 to 6.63	0.005	2.74	0.03 to 5.44	0.047
Korean	− 2.61	− 4.33 to − 0.89	0.003	− 4.54	− 6.32 to − 2.75	< 0.001
BMI (kg/m^2)						
< 50	Ref	–	–	Ref	–	–
≥ 50	6.01	4.39 to 7.63	< 0.001	5.60	3.95 to 7.25	< 0.001
Time	0.46	− 0.01 to 0.93	0.055	0.46	− 0.004 to 0.93	0.052
Preop T2DM	− 1.66	− 3.01 to − 0.32	0.015			

mean %EWL (all $p < 0.001$). Presence of T2DM preoperatively had a negative impact on both %TWL ($p = 0.015$) and %EWL ($p < 0.001$) in univariate analysis. Statistical significance was however not achieved in the adjusted analysis for the former (Fig. 1).

Comparing weight loss outcomes within the same ethnic group from different countries (Table 4), Chinese from Taiwan and Malaysia have significantly higher mean %TWL and %EWL than those in Singapore ($p < 0.001$). There was however no difference in mean %TWL and %EWL between Chinese in Hong Kong and Singapore. On average, the Malays from Malaysia and Indians from Malaysia and India also have significantly higher %TWL and %EWL than their counterparts in Singapore.

Discussion

This study demonstrates that there are indeed significant differences in bariatric surgery outcomes among Asian ethnicities with the best outcomes in Japanese and the poorest outcomes in Malays. The Malay population are at the highest risk of obesity and its consequent sequelae. Not only do they have the highest prevalence of obesity in Singapore [11, 12] and Malaysia [27], our study suggests that they are also more resistant to bariatric surgery as compared to the rest of the Asian ethnicities. This closely mimics the obesity and weight loss patterns in African-Americans in the USA who when compared to their Caucasian counterparts have been found to weigh more and lose significantly less weight after all modes of anti-obesity therapy. These include diet, exercise, behaviour modification, and bariatric surgery [22, 28–30].

In the African-American population, causes for these differences while not fully elucidated have been better studied than in the Malay population and are believed to involve a combination of lifestyle, biological, psychological, and socioeconomic factors. With regard to lifestyle, several studies have shown that African-American females lead more sedentary lifestyles and consume higher caloric diets than their Caucasian counterparts [31–33]. Similarly, in Singapore, the 2004 National Nutrition Report showed that Malays consumed more sweet beverages and deep-fried food and tended to include less whole grains, fruit, and vegetables in their diets than the general population. Their diet was also the highest in mean daily caloric (2533 kcal) and fat intake (85.7 g) [34]. This however has not been conclusively demonstrated to have short- or long-term effects on obesity and would be an interesting area of study.

Lower socioeconomic status has also been associated with higher prevalence of obesity in Western studies and this has been identified as one of the contributing factors of obesity in African-Americans [35–41]. National surveys conducted by

Table 3 Univariate association and repeated measures analysis between %EWL and baseline demographic and clinical characteristics

Variables	Coefficient	95% CI	*p* value	Coefficient	95% CI	*p* value
Age(years)			< 0.001			< 0.001
≤ 30	Ref	–	–	Ref	–	–
31–40	− 8.48	− 14.10 to − 2.85	0.003	− 5.60	− 11.38 to 0.19	0.058
41–50	− 14.35	− 19.89 to − 8.82	< 0.001	− 8.75	− 14.75 to − 2.75	0.004
> 50	− 23.61	− 29.07 to − 18.15	< 0.001	− 16.73	− 22.77 to − 10.69	< 0.001
Gender						
Female	Ref					
Male	− 6.62	− 10.49 to − 2.75	0.001	− 4.71	− 8.39 to − 1.02	0.012
Ethnicity			< 0.001			
Caucasian	Ref	–	–	Ref	–	–
Chinese	18.15	12.73 to 23.56	< 0.001	10.47	4.71 to 16.23	< 0.001
Malay	− 4.18	− 9.35 to 0.98	0.112	− 6.25	− 11.17 to − 1.33	0.013
Indian	− 1.12	− 5.88 to 3.63	0.643	− 2.08	− 6.81 to 2.64	0.388
Japanese	18.55	10.33 to 26.77	< 0.001	17.48	9.74 to 25.22	< 0.001
Korean	17.16	11.27 to 23.05	< 0.001	9.13	3.10 to 15.15	0.003
BMI (kg/m^2)			< 0.001			
< 50	Ref	–	–	Ref	–	–
≥ 50	− 23.33	− 26.98 to − 19.67	< 0.001	− 17.49	− 20.92 to − 14.06	< 0.001
Preop T2DM	− 11.90	− 16.63 to − 7.18	< 0.001	− 5.81	− 10.57 to − 1.05	0.017
Time	0.82	− 0.52 to 2.16	0.231	1.05	− 0.29 to 2.39	0.124

the Ministry of Culture, Community and Youth of Singapore (MCCY) showed that the Malay community have had the lowest household income and educational attainment across all levels since the 1980s as compared to other ethnic groups [42] and this is likely to have a similar bearing on obesity patterns. Besides lifestyle and dietary differences, a lower socioeconomic and education status also affects access to healthcare opportunities and education. A study by the Health Promotion Board (HPB), Singapore, demonstrated that the Malay population had both a lower uptake rate for screening programmes and poorer follow-up rates as compared to other ethnic groups [43].

These socioeconomic factors however are unlikely to fully explain why similar patterns in obesity and weight loss are seen in Malays from Malaysia, where they form the population majority. This suggests that biological factors may also be at play. Studies in African-Americans show that they have a (i) greater capacity for fat uptake and storage [44], (ii) higher rate of triglyceride synthesis [45], (iii) reduced fat turnover [46], and (iv) decreased fat oxidation by skeletal muscle [47] as

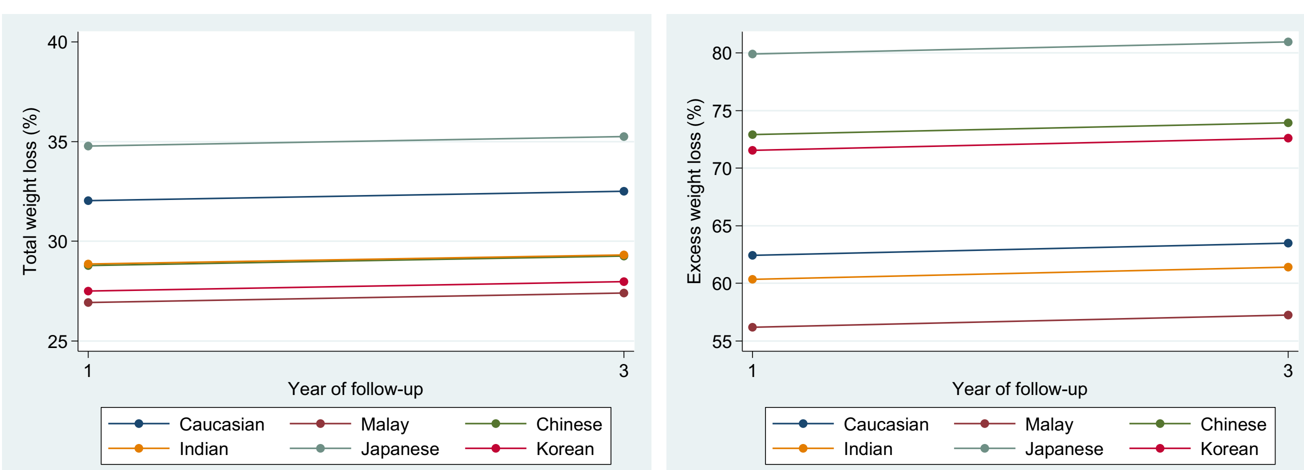

Fig. 1 Comparisons in %TWL and %EWL between ethnicities

Table 4 Repeated measures analysis of %TWL and % EWL among similar ethnicities from different countries adjusted for age group, gender, baseline BMI, and effect of time

Ethnicity	Country	%TWL			% EWL		
		Coefficient	95% CI	*p* value	Coefficient	95% CI	*p* value
Chinese	Singapore	Ref	–	–	Ref		
	Hong Kong	0.02	− 3.42 to 3.46	0.990	0.07	− 10.29 to 10.42	0.990
	Taiwan	6.39	3.88 to 8.90	< 0.001	28.50	20.83 to 36.17	< 0.001
	Malaysia	6.46	2.88 to 10.04	< 0.001	14.64	7.12 to 22.15	< 0.001
Malays	Singapore	Ref	–	–	Ref		
	Malaysia	5.32	2.84 to 7.81	< 0.001	15.60	7.86 to 23.34	< 0.001
Indians	Singapore	Ref	–	–	Ref	–	–
	India	4.08	0.65 to 7.52	0.020	7.82	− 0.88 to 16.52	0.078
	Malaysia	3.78	0.18 to 7.38	0.039	16.73	8.31 to 25.16	< 0.001

compared to Caucasians. Similar markers of metabolism have not been studied in the Malay and larger Asian population.

Next, the Chinese and Koreans in our study interestingly demonstrated poorer %TWL but significantly better %EWL as compared to Caucasians—though they lose less total weight, it is a greater proportion of their excess weight. This is likely because %EWL as a weight loss outcome measurement favours those who have a lower pre-operative weight. The Japanese, however, maintain higher mean %TWL and %EWL than the Chinese and Koreans, who are presumably their closest genetic cousins. These differences are likely to be attributed to lifestyle and cultural differences.

Overall prevalence of adult obesity in Japan is only 3.6% compared to 32.0% in America [48]. Senauer et al. reported that the average Japanese consumed 200 fewer calories as compared to the average American, had a healthier and more traditional dietary habit, and were also physically more active due to convenience and affordability of public transportation [49]. In our study, the Japanese cohort also stood out as having the highest proportion of male patients (52.1%) and the highest proportion of patients with type 2 diabetes (35.8%). Japanese men have been found to have higher prevalence of obesity and metabolic syndrome which has been attributed to job demands related to long working hours, stress perception, eating behaviours, chronic smoking, and alcoholism [50, 51]. The gender difference may also be reflective of the underlying cultural perception towards obesity and body image in Japan, where the desire for an underweight body image is especially prevalent among women. Despite having obesity prevalence of only 2–10% in studies of both adolescents and adults, close to 50% of Japanese women still perceived themselves as being overweight [52, 53]. These cultural perceptions may form strong motivators for weight loss in the Japanese population.

Additional analyses carried out in our study included a comparison of weight loss outcomes within same ethnicity groups across different countries, with Singapore as the reference. Our results showed that weight loss outcomes across all three ethnicities (namely Chinese, Malays, and Indians) were poorer in Singapore as compared to other countries with the only exception of Chinese in Hong Kong where no significant difference was found. This suggests that besides biological make-up, socioeconomic and cultural factors that are unique to each country may have an impact on weight loss outcomes. The fact that significant difference was not found between Chinese in Singapore and Hong Kong may imply that socioeconomic factors may be a greater contributing factor influencing weight loss outcomes as the economic standing of both countries are very similar.

The compliance rate to follow-up did not correlate directly with improved weight loss outcomes. Additionally, the impact of differences in compliance between ethnic groups on weight loss outcomes could not be reasonably accounted for in the final analysis as the data of patients lost to follow-up would not have been available. The follow-up rates at 1 year however are less widely spread with the described differences above already seen. Given that the effect of time had no significant impact on weight loss outcomes, differences seen are still likely to be reflective. This is especially true for the Japanese and Malays who are at the extremes in terms of %EWL and %TWL of this cohort.

Strengths, Limitations, and Future Research

Our study is the first to look at Asian ethnicities in bariatric surgery with multi-centre involvement. This allows us to draw comparisons not just across diverse ethnicities but also across geographical boundaries, demonstrating the interplay of not just biological, but also cultural and socioeconomic factors. Therein, however, also lies our weakness, as this increases the propensity for bias and confounding with certain ethnic groups being represented by single centres (Japanese) and others being represented more in certain countries than others.

These biases are likely to be further exacerbated by the inherent limitations of a retrospective study.

Additionally, our study was only able to examine weight loss outcomes at up to 36 months where 60 months would have been ideal. There was also wide variability in the availability and quality of comorbidity data at follow-up between centres and this limited our ability to analyse and comment on the differences seen between ethnic groups in this respect. These may be better answered by prospective studies designed to examine long-term outcomes.

One further limitation of our study is the inability to account for variations in surgical technique between surgeons—the bougie size used during surgery varied between 34Fr and 38Fr and the distance from pylorus where stapling began ranged between 2 and 6 cm.

The interplay between biological, cultural, socioeconomic, and psychological factors resulting in ethnic differences in outcomes may never be fully understood. Future research in bariatric surgery could focus on (i) the identification of high-risk ethnicities such as the Malays and African-Americans and direct resources towards designing epidemiological and clinical interventions that target modifiable risk factors, (ii) projection of evidence-based expectations for patients in terms of weight loss after bariatric surgery considering ethnicity and other major factors (age, gender, initial BMI), and (iii) implementation of prospective studies to conclusively determine the impact of ethnicity on weight loss, and evaluate its possible impact on long-term outcomes such as cardiovascular morbidity, mortality, and life expectancy.

Conclusion

In conclusion, our study shows favourable weight loss outcomes after bariatric surgery were observed in Japanese, Chinese, and Koreans, while less favourable outcomes were noted in Malays as compared to Caucasians. Contributing factors are multi-factorial and prospective studies are necessary to determine the impact of Asian ethnicity on long-term outcomes after bariatric surgery.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interests.

Statement of Informed Consent No formal consent was required as this was a retrospective study.

A Statement of Human and Animal Rights This study has been approved by the Institutional Review Board of each institution and all procedures were conducted in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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