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Body Mass Index (BMI) assessment among Macau students: age group differences and weight management strategies

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ABSTRACT: There is evidence that rapid weight gain during the first year of life is associated with being overweight later in life. Therefore, overweight tendencies need to be detected at an appropriate age, and suitable strategies need to be implemented for weight management to achieve optimal long-term health. The objective of this study was to investigate comparisons in BMI status and associated categories in male and female students over ten years in two phases, including 2008-2013 and 2009-2014. Weight and height data were collected to obtain BMI (Body Mass Index) over ten years in two phases. The first phase occurred from 2008 to 2013, and the second phase occurred from 2009 to 2014 in a population of 10846 school children (Males: 6970, 64.3%, and females: 3875, 35.7%) in Macau. Their ages ranged from 6 years old in 2008 to 11 years old in 2013. The same age range was observed in the second phase, i.e., 2009-2014. Statistical analyses included descriptive statistics, such as the mean, standard deviation, t-tests to determine gender differences (year-wise) and a Chi square test for independence to determine the relationship between BMI (Underweight, Standard, Overweight and Obese) and age groups. In the first phase (2008-2013), the findings indicated a higher BMI level among the male students than the female students across all age groups (2008 $t = 5.24$, 2009 $t = 88.25$, 2010 $t = 11.32$, 2011 $t = 17.45$, 2012 $t = 19.70$ and 2013 $t = 19.92$). In the second phase (2009-2014), a higher BMI level was found among the male students than the female students across all age groups (2009 $t = 2.68$, 2010 $t = 2.886$, 2011 $t = 3.076$, 2013 $t = 4.228$, and 2014 $t = 2.405$). The results of the two phases combined (2008 to 2014 and 2009 to 2014) revealed that male students in 2008 had a higher BMI level than their counterparts in 2009 in the two age categories (8 years $t = 3.025$ and 11 years $t = 3.377$). Female students in the second phase (2009-2014) showed a higher BMI level than their male counterparts (9 years, $t = 3.151$). The results indicate the need to have focused strategies and structured interventions for male students at the critical age range of 8 to 9 years old. The results

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of this study also imply the need for the delivery of suitable school intervention activities at the appropriate time. Specifically, the prevention of weight gain should start early in life to encourage the development of healthier behaviours and habits throughout childhood and later ages.

Key words: Body Mass Index, children's health growth, overweight, obesity

Introduction

Over the last three decades, pandemic obesity has doubled globally (World Health Organization 2013) and kills more of the world's population than being underweight. It is a major contributing factor in many metabolic disorders, such as blood pressure, hypercholesterolemia, high triglycerides and insulin resistance. According to a global estimate by the World Health Organization (WHO) in 2005, there were approximately 1.6 billion overweight persons aged 15 years and older, and among them, at least 400 million adults were obese (WHO 2006). In 2014, more than 1.9 billion adults aged 18 years and older were overweight. Of these, over 600 million were obese. Therefore, 39% of adults aged 18 years and older were overweight and 13% were obese. Additionally, 41 million children under the age of 5 were overweight or obese in 2014. In the US, 3 in 4 men (74%) are considered overweight or obese, and more than one-third (35.7 percent) of adults are obese, with approximately 1 in 20 (6.3%) people having extreme obesity (NIDDK USA 2012). Similarly, in China, the prevalence of excess weight is 25.0%, and the prevalence of obesity is 4.0% (Yu et al. 2012; Cai et al. 2014). In Korea, the prevalence of excess weight is 27.4%, and the prevalence of obesity is 3.2% (Ambady and Chamukuttan 2010). Worldwide, at least 2.8 million people die each year as a result of being overweight or obese, and an estimated 35.8 million (2.3%) global DALYs (Disability Adjusted Life Years) are affected by excess weight or obesity. Shockingly, the number of people globally with a body mass index (BMI) greater than 30 has risen from 105 million in 1975 to 641 million in 2014, and this upward trend is predicted to continue over the coming decades (Walls et al. 2012, The journal.ie 2017; Daily Record 2016; Kelland 2016). An epidemic of overweight- and obesity-related diseases, such as diabetes and cardiovascular disease (CVD), is prevalent in many Asian countries. Migration from rural to urban areas and rapid socio-economic transitions are associated with the lifestyle changes that result in decreased levels of physical activity and increased intake of energy-dense diets (Ramachandran et al. 2012; Ahmed et al. 2016). A worrisome trend of excess weight and obesity in childhood tends to follow into adulthood, causing an increased risk for cardiovascular disease and type 2 diabetes (Adela and Frank 2015; Frank and Michelle 2015; Neslihan 2014, Ahmed et al. 2017). Consequently, elevated health and economic burdens have become emerging problems worldwide (WHO 2005; Popkin 2006) and the estimated cost of physical inactivity to healthcare systems internationally was (INT$) $53.8 billion in 2013, in which high-income countries bear a larger proportion of the economic burden (80.8% of health-care costs and 60.4% of indirect costs) and low-income and middle-income countries have a larger proportion of the disease burden (75.0% of disability-adjusted life-years DALYs) (Ding et al. 2016).

Several studies have addressed the question of critical time windows for

weight development. There is now consistent evidence that growth during the first year of life is associated with being overweight later in childhood, adolescence or adulthood (Baird et al. 2005; Dennison et al. 2006). The prevention of being overweight in childhood is high on the public health agenda, but the most promising windows of opportunity for effective intervention need to be identified (Baird et al. 2005). There is reason to believe that once excess weight and obesity have developed in childhood, it is difficult to reverse the situation. The latest report from the Centers for Disease Control and Prevention, the CDCP (2015), says that obesity now affects 1 in 6 children and adolescents in the United States. If this is the case, the application of suitable intervention activities at the beginning of such a sensitive period will be important. WHO member states have committed to a "10% relative reduction in prevalence of insufficient physical activity" by 2025.

The goal of this study was to compare body mass index (BMI) between male and female students in Macau. The study was conducted in two phases 2008 to 2013 and 2009 to 2014 with independent data set garnered each year in the two phases mentioned above. Furthermore, it also assesses the prevalence and estimates of BMI categories (underweight, overweight and obesity) in the Macau student's population using BMI threshold for each categories and the equivalent sex and age-specific measurement.

Method

Participants

Over 10 years and in two phases, the data for the present study was collected from a total sample of 10846 school children (6970 males, 64.3% and 3875 females, 35.7%). The first phase occurred from 2008 to 2013, and the second phase occurred from 2009 to 2014. In the first phase, a sample of 5369 (3368 males and 2001 females) children participated in the study. In the second phase of the study, 5477 (3603 males and 1874 females) children participated. Our study collected data only on students whose ages ranged between 6 to 11 years only. Their ages ranged from 6 years old in 2008 to 11 years old in 2013, with the same age range in 2009–2014. However, they are not the same students have been measured over two phases years (2008–2009 and 2009–2014) with independent data set each-year. During this period, all students in the same class were observed, but because some students left and others joined, the number of students in each year of observation differed according to the following figures that represent the mean and the standard deviation of male and female participants (Table 1).

Tool used in the study

BMI was calculated as the primary variable in this study and was defined as the weight in kilograms divided by the height in metres squared (kg/m^2). To determine the students' body masses relative to their heights and weights, BMI was further categorized into one of four groups, namely, Underweight, Standard Weight, Overweight and Obese, according to the norms and indicators used in Taiwan from 2008 to 2011 (Ministry of Education 2016).

Statistical analysis

To carry out the objectives of the study, descriptive statistics, such as the mean

Table 1. Gender and year-wise descriptive statistics of male and female children BMI (2008–2013 and 2009–2014)

Year	Gender	Age		Height		Weight		BMI		N
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
2008–2013										
2008	Male	6.47	0.55	122.77	6.14	23.82	5.23	15.70	2.75	556
	Female	6.50	0.58	121.96	6.42	22.61	4.62	15.13	2.33	338
	Total	6.48	0.56	122.46	6.25	23.36	5.04	15.49	2.61	894
2009	Male	7.50	0.57	128.24	6.12	27.14	6.61	16.37	3.01	569
	Female	7.55	0.64	126.59	6.67	25.37	5.56	15.71	2.40	328
	Total	7.52	0.59	127.64	6.37	26.49	6.30	16.13	2.82	897
2010	Male	8.56	0.62	133.47	7.12	30.07	8.28	16.72	3.49	594
	Female	8.56	0.64	131.90	7.38	28.58	7.31	16.23	2.90	330
	Total	8.56	0.63	132.91	7.25	29.54	7.97	16.54	3.29	924
2011	Male	9.62	0.73	139.04	7.50	36.04	9.96	18.54	3.98	612
	Female	9.55	0.67	139.05	7.74	33.63	8.27	17.21	3.12	338
	Total	9.60	0.71	139.04	7.58	35.18	9.46	18.07	3.75	950
2012	Male	10.69	0.77	145.98	8.77	41.85	12.35	19.38	4.32	525
	Female	10.58	0.65	147.03	7.63	38.66	9.51	17.73	3.36	333
	Total	10.65	0.73	146.39	8.36	40.61	11.43	18.74	4.05	858
2013	Male	11.72	0.81	152.57	9.38	47.19	13.63	20.02	4.37	512
	Female	11.66	0.77	152.54	7.24	44.63	10.02	19.03	3.39	334
	Total	11.69	0.79	152.55	8.60	46.18	12.39	19.63	4.04	846
2009–2014										
2009	Male	6.52	0.60	124.97	6.59	24.83	5.63	15.78	2.59	831
	Female	6.65	0.64	124.57	6.77	24.00	4.98	15.39	2.45	508
	Total	6.57	0.62	124.82	6.66	24.51	5.41	15.63	2.54	1339
2010	Male	7.20	0.42	126.84	6.76	27.04	6.03	16.70	2.84	550
	Female	7.14	0.27	125.43	6.84	25.40	4.80	16.11	2.53	269
	Total	7.18	0.38	126.37	6.82	26.50	5.70	16.51	2.76	819
2011	Male	8.22	0.46	133.17	6.24	30.98	7.41	17.31	3.12	538
	Female	8.24	0.45	133.19	6.96	29.56	6.68	16.59	3.21	274
	Total	8.23	0.46	133.18	6.49	30.50	7.20	17.07	3.17	812
2012	Male	9.38	0.63	138.87	7.02	35.96	10.34	18.46	4.37	557
	Female	9.29	0.52	139.89	7.49	36.18	12.44	18.35	5.65	270
	Total	9.35	0.59	139.20	7.19	36.03	11.06	18.42	4.82	827
2013	Male	10.16	0.33	144.50	8.36	40.42	11.66	19.09	3.99	561
	Female	10.19	0.36	146.83	7.47	39.24	8.37	18.07	2.86	271
	Total	10.17	0.34	145.26	8.15	40.03	10.71	18.76	3.69	832
2014	Male	11.28	0.51	153.17	9.01	45.44	13.12	19.13	4.24	566
	Female	11.24	0.45	153.58	6.74	43.93	8.64	18.53	2.94	282
	Total	11.27	0.49	153.31	8.32	44.94	11.84	18.93	3.87	848
Total	Male	8.83	1.85	136.38	12.46	33.76	12.23	17.67	3.89	6971
	Female	8.81	1.84	136.15	12.98	32.12	10.84	16.90	3.39	3875
	Total	8.82	1.84	136.30	12.65	33.17	11.78	17.39	3.74	10846

and the standard deviation, were used to analyse basic features. Furthermore, to determine the difference between the sexes in the variables, an independent t-test was used. Finally, a Chi-square was implemented to explore the BMI categories among the cohorts (age- and year-wise). A one-way between-groups multivariate analysis of variance was performed to investigate age group differences in the height, weight and BMI.

Ethical Concern

Official approval was received from the University of Macau. The Principal Investigator and his team approached the school principals for final consideration to continue with the data collection. Written consent was received from the participating schools, and structured strategies were implemented to secure the full participation of the students. Students had the right to be involved (Shaw et al. 2011), and successful participation of the students in this research was associated with their understanding of the process. Briefing of every student was conducted, and the parents were informed and provided with a handbook and an information brochure to assist in their understanding of the data collection. The schools were provided with the necessary apparatus to conduct height and weight measurements and calculate the BMI status of every student.

Results

Table 1 provides a gender and year-wise description of the parameters used in this study. The results show a steady increase in the BMI with age for both male and female students, with slightly higher BMIs in the male students than in the female students. The standard deviation also increases with age, suggesting that there is more variance in the BMI of the students as they get older.

At a younger age, the BMI of students is fairly similar, but as the students grow older, there is a trend towards bigger differences among them relative to BMI, regardless of gender. These differences between gender and age groups were further analysed to determine whether these differences were significant, and the results are presented in Table 2.

Interpretation based on the first phase (2008 to 2013)

Independent-samples t-tests were conducted to determine the gender group differences for the height, weight and BMI of the school children in each age group. The results are presented in Table 2. When the heights of the male and female students were compared, a significant difference was found only for the 7-year-old male (M 128.24 ± 6.12) and female (126.59 ± 6.67; t (895) = 3.77, p=0.001) students and the 8-year-old male (M 133.47 ± 7.12) and female (131.90 ± 7.38 t (922)=3.15, p=0.002) students. No significant gender differences were found for height in 6-year-old and 9- to 11-year-old students. When the weights of the male and female students were compared, a significant difference was found for gender in all age groups. The relevant means and standard deviation scores are presented in Table 1, and the significant differences in weight between the gender groups are presented in Table 2. Overall, the weights of the male students in all age categories were significantly higher than the weights of the female students in each age group. When the BMI of the male and female

Table 2. The independent t–test for height, weight and BMI of the school students of Macau from the year 2008 to 2013 and 2009 to 2014

Male between Female	*t*–test for Equality of Means					Male between Female	*t*–test for Equality of Means				
2008 to 2013	*t*	df	Sig. (2-tailed)	MD	SED	Variables 2009 to 2014	*t*	df	Sig. (2-tailed)	MD	SED
Height (6 years – 2008)	1.88	892	0.06	0.81	0.43	Height 2009 (6 years)	1.05	1337	0.29	0.39	0.37
Height (7 years – 2009)	3.77*	895	0.00	1.65	0.43	Height 2010 (7 years)	2.77*	817	0.00	1.40	0.50
Height (8 years – 2010)	3.15*	922	0.00	1.56	0.49	Height 2011 (8 years)	–0.03	810	0.97	–.015	0.48
Height (9 years – 2011)	1.32	948	0.18	–1.13	0.85	Height 2012 (9 years)	–1.91	825	0.05	–1.01	0.53
Height (10 years – 2012)	1.79	856	0.07	–1.05	0.58	Height 2013 (10 years)	–4.05*	591.40	0.00	–2.33	0.57
Height (11 years – 2013)	0.04	844	0.96	.028	0.60	Height 2014 (11 years)	–0.73	720.24	0.46	–0.40	0.55
Weight (6 years – 2008)	3.51*	892	0.00	1.21	0.34	Weight 2009 (6 years)	2.80*	1172.46	0.00	0.82	0.29
Weight (7 years – 2009)	4.08*	895	0.00	1.76	0.43	Weight 2010 (7 years)	4.21*	651.04	0.00	1.64	0.39
Weight (8 years – 2010)	2.69*	921	0.00	1.46	0.54	Weight 2011 (8 years)	2.75*	602.55	0.00	1.41	0.51
Weight (9 years – 2011)	3.80*	948	0.00	2.42	0.63	Weight 2012 (9 years)	–0.27	825	0.78	–0.22	0.82
Weight (10 years – 2012)	4.01*	856	0.00	3.18	0.79	Weight 2013 (10 years)	1.66	711.37	0.09	1.18	0.70
Weight (11 years – 2013)	2.94*	844	0.00	2.55	0.86	Weight 2014 (11 years)	2.00*	783.10	0.04	1.51	0.75
BMI (6 years – 2008)	3.20*	892	0.00	0.57	0.17	BMI 2009 (6 years)	2.68*	1337	0.00	0.38	0.14
BMI (7 years – 2009)	3.38*	895	0.00	0.65	0.19	BMI 2010 (7 years)	2.88*	817	0.00	0.59	0.20
BMI (8 years – 2010)	2.16*	922	0.03	0.48	0.22	BMI 2011(8 years)	3.07*	810	0.00	0.72	0.23
BMI (9 years – 2011)	5.32*	948	0.00	1.33	0.25	BMI 2012 (9 years)	0.32	825	0.74	0.11	0.35
BMI (10 years – 2012)	5.93*	856	0.00	1.65	0.27	BMI 2013 (10 years)	4.22*	712.707	0.00	1.02	0.24
BMI (11 years – 2013)	3.51*	844	0.00	.992	0.28	BMI 2014 (11 years)	2.40*	759.019	0.01	0.60	0.25

'*'= *Significant*, *df* = 1.960.

Table 3. The independent *t*-test on comparison for height, weight and BMI of the school students of Macau from the year 2008 to 2013 and 2009 to 2014 the two phases combine

Male and Male	*t*-test for Equality of Means					Male and Female	*t*-test for Equality of Means				
Variables	*t*	df	Sig. (2-tailed)	MD	SED	Variables	*t*	df	Sig. (2-tailed)	MD	SED
Height (6 years – 2008–2009)	–6.25*	1385	0.00	–2.19	0.35	Height (6 years – 2008–2009)	–5.61*	844	0.00	–2.61	0.46
Height (7 years – 2008–2009)	3.65*	1117	0.00	1.40	0.38	Height (7 years – 2008–2009)	2.07*	595	0.03	1.15	0.55
Height (8 years – 2008–2009)	0.74	1130	0.45	0.29	0.40	Height (8 years – 2008–2009)	–2.18*	602	0.03	–1.28	0.58
Height (9 years – 2008–2009)	0.39	1167	0.69	0.16	0.42	Height (9 years – 2008–2009)	–1.34	606	0.18	–0.83	0.62
Height (10 years – 2008–2009)	2.85*	1084	0.00	1.48	0.52	Height (10 years – 2008–2009)	–0.78	602	0.43	–0.58	0.73
Height (11 years – 2008–2009)	–1.08	1076	0.27	–0.60	0.56	Height (11 years – 2008–2009)	–1.83	614	0.06	–1.04	0.56
Weight (6 years – 2008–2009)	–3.34*	1385	0.00	–1.00	0.30	Weight (6 years – 2008–2009)	–4.09*	844	0.00	–1.39	0.33
Weight (7 years – 2008–2009)	0.25	1117	0.79	0.09	0.37	Weight (7 years – 2008–2009)	–0.06	595	0.94	–0.02	0.43
Weight (8 years – 2008–2009)	–1.92	1130	0.05	–0.90	0.46	Weight (8 years – 2008–2009)	–1.70	602	0.08	–0.97	0.57
Weight (9 years – 2008–2009)	0.14	1167	0.88	0.08	0.59	Weight (9 years – 2008–2009)	–3.02*	606	0.00	–2.54	0.84
Weight (10 years – 2008–2009)	1.95	1084	0.05	1.42	0.72	Weight (10 years – 2008–2009)	0.32	602	0.74	0.20	0.61
Weight (11 years – 2008–2009)	2.13*	1076	0.03	1.74	0.81	Weight (11 years – 2008–2009)	0.92	614	0.35	0.70	0.76
BMI (6 years – 2008–2009)	–0.51	1385	0.61	0–.07	0.14	BMI (6 years – 2008–2009)	–1.57	844	0.11	–0.26	0.16
BMI (7 years – 2008–2009)	–1.89	1117	0.05	–0.33	0.17	BMI (7 years – 2008–2009)	–1.96	595	0.04	–0.39	0.20
BMI (8 years – 2008–2009)	–3.02*	1130	0.00	–0.59	0.19	BMI (8 years – 2008–2009)	–1.47	602	0.14	–0.36	0.24
BMI (9 years – 2008–2009)	0.32	1167	0.74	0.08	0.24	BMI (9 years – 2008–2009)	–3.15*	606	0.00	–1.13	0.36
BMI (10 years – 2008–2009)	1.14	1084	0.25	0.29	0.25	BMI (10 years – 2008–2009)	–1.31	602	0.18	–0.33	0.25
BMI (11 years – 2008–2009)	3.37 *	1076	0.00	0.88	0.26	BMI (11 years – 2008–2009)	1.91	614	0.05	0.49	0.25

''= Significant, df* = 1.960.

Table 4. Year-wise categorization on BMI level between male and female

BMI Categories	Count	Gender		Total
		Male	Female	
Underweight	Count	1359	769	2128
	% within Indicator	63.9%	36.1%	100.0%
Standard	Count	3952	2365	6317
	% within Indicator	62.6%	37.4%	100.0%
Overweight	Count	861	432	1293
	% within Indicator	66.6%	33.4%	100.0%
Obesity	Count	798	309	1107
	% within Indicator	72.1%	27.9%	100.0%
Total	Count	6970	3875	10845
	% within Indicator	64.3%	35.7%	100.0%

students was compared, a significant difference was also found for gender in all age groups. The relevant means and standard deviation scores are presented in Table 1, and the significant differences in BMI between the gender groups are presented in Table 2. Overall, the BMI of the male students in all age categories was significantly higher than the BMI of the female students in each age group. A further analysis to determine the number of students in each BMI category for each age group was conducted, and the results are presented in Table 4.

Interpretation based on Second Phase (2009 to 2014)

When the heights of the male and female students were compared, a significant difference was found only in the 7-year-old male (M 128.24 ± 6.12) and female (126.59 ± 6.67; t (895) = 3.77, p=0.001) students and in the 10-year-old male (M 133.47 ± 7.12) and female (131.90 ± 7.38 t (922)=3.15, p=0.002) students. No significant gender differences were found for height in 6-, 8-, 9- or 11-year-old students. When the weights of the male and female students was compared, a significant difference was observed for gender in all age groups. However, in the years 2012 and 2013, the data did not show any significant difference between boys and girls. The relevant means and standard deviation scores are presented in Table 1, and the significant differences for weight between the gender groups are presented in Table 2. Overall, the weight of the male students in all age categories was significantly higher than the weight of the female students in each age group. When the BMIs of the male and female students were compared, a significant difference was also found for gender in all age groups. The relevant means and standard deviation scores are presented in Table 1, and the significant differences in BMI between the gender groups are presented in Table 2. Overall, the BMI of the male students in all age categories was significantly higher than the BMI of the female students in each age group, except for the year 2012 which did not show any significant difference between the sexes. A further analysis to determine the number of students in each BMI category for each age group was performed, and the results are presented in Table 3.

Interpretation based on Male students' data from 2008 to 2013 and 2009 to 2014

Male Students' Heights in the years *2008 to 2013* and *2009 to 2014* were compared, and significant differences were found in the 6-year-old male (2008–2013) (*M* 122.77 ± 6.14) and the 2009–2014 male (124.97 ± 6.254; *t* (1385) = 6.25, $p<0.001$) students, the 7-year-old male (2008–2013) (*M* 128.24 ± 6.12) and 2009–2014 male (126.84 ± 6.76; *t* (1117)=3.652, $p<0.000$) students, and the 10-year-old male (2008–2013) (*M* 145.98 ± 8.77) and 2009–2014 male (144.50 ± 8.36; *t* (1084) = 2.856, $p<0.001$) students. No significant gender differences were found for height in 8–9- or 11-year-old students. When the weights of the students were compared, significant differences were found in the 6-year-old male (2008–2013) (*M* 23.82 ± 5.23) and 2009–2014 male (24.83 ± 5.63; *t* (1385) = 3.341, $p=0.001$) students and in the 11-year-old male (2008–2013) (*M* 47.19 ± 13.63) and 2009–2014 male (45.44 ± 13.12; *t* (1076) = 2.139, $p=0.001$) students. No significant gender differences were found for height in 7-, 8-, 9- or 10-year-old students. Significant differences in BMI were found in the 8-year-old male (2008–2013) (*M* 16.72 ± 3.49) and 2009–2014 male (16.59 ± 3.21); *t* (1130) = 3.025, $p=0.003$) students and in the 11-year-old male (2008–2013) (*M* 19.03 ± 3.39) and 2009–2014 male (19.13 ± 4.24); *t* (1076) = 3.377, $p=0.001$) students. No significant gender differences were found for height in 6-, 7-, 9- and 10-year-old students. A further analysis to determine the number of students in each BMI category for each age group was performed, and the results are presented in Table 4.

Interpretation based on Female students' data from 2008 to 2013 and 2009 to 2014

Female Students' Heights in the years *2008 to 2013* and *2009 to 2014* were compared, and a significant differences were found only in the 6-year-old female (2008–2013) (*M* 121.96 ± 6.42) and 2009–2014 female (124.57 ± 6.77; *t* (844) = 5.61, $p =0.000$) students, the 7-year-old female (2008–2013) (*M* 126.59 ± 6.67) and 2009–2014 female (125.43 ± 6.84; *t* (595) = 2.078, $p =0.038$) students, and in the 8-year-old female (2008–2013) (*M* 131.90 ± 7.38) and 2009–2014 female (133.19 ± 6.96; *t* (602) = 2.181, $p=0.030$) students. No significant differences were found for height in 9-, 10-, or 11-year-old female students. When the weights of the students were compared, significant differences were found in the 6-year-old female (2008–2013) (*M* 22.61 ± 4.62) and 2009–2014 female (24.00 ± 4.98; *t* (844) = 4.094, $p=0.001$) students and in the 9-year-old female (2008–2013) (*M* 33.63 ± 8.27) and 2009–2014 female (36.18 ± 12.44; *t* (606) = 3.022, $p=0.001$) students. No significant gender differences were found for height in 7-, 8-, 10- or 11-year-old female students. A significant difference in BMI was found in 8-year-old female (2008–2013) (*M* 16.23 ± 2.90) and 2009–2014 female (16.59 ± 3.21); *t* (606) = 3.151, $p=0.003$) students. No significant gender differences were found for BMI in 6-, 7-, 9-, 10- or 11-year-old students. A further analysis to determine the number of students in each BMI category for each age group was conducted, and the results are presented in Table 4.

A one-way between-groups multivariate analysis of variance (MANOVA)

was performed to investigate age group differences in anthropometric measures. This was done to provide an explanation of trends over time. Three dependant variables were used: height, weight and BMI, while age was the independent variables in the two study waves (phases). Preliminary assumption testing (Box's Test of Equality of Covariance Matrices ($p<0.00$) and Levene's Test of Equality of Error Variances ($p<0.001$) showed possible violation of the assumptions for homogeneity and equality of variance. This can be explained by the large sample size of 6 – 11 year old children (n = 10199) that contributes to the strictness of the tests. There was a statistically

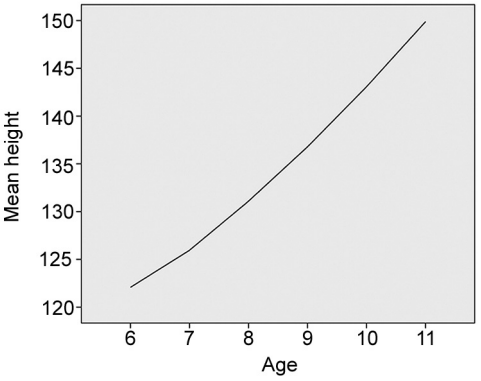

Fig. 1. Mean height across all ages

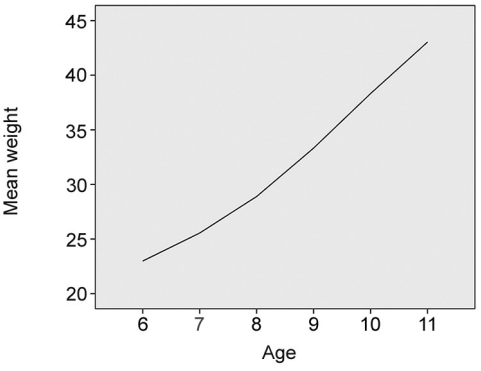

Fig. 2. Mean weight across all ages

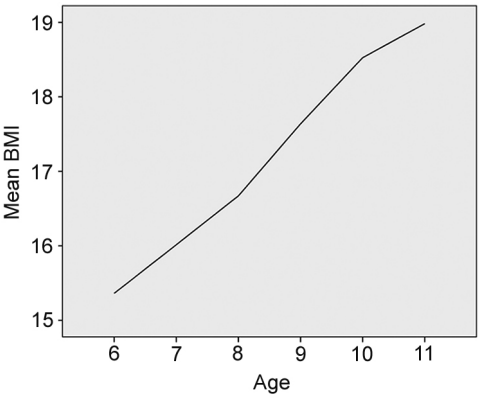

Fig. 3. Mean BMI across all ages

significant difference between the age groups (6–11years) on the combined dependent variables, F (15, 27912.42) = 859.11, $p<0.001$ Wilkes Lambda = 0.351; partial eta squared = .295. When the dependent variables were considered separately, all three dependent variables reached statistical significance with a alpha level at .05 for height, F (5,10113) = 3381.94, $p<0.001$; partial eta squared = 0.626, weight (5,10113) = 1299.87, $p=0.001$; partial eta square =0.391, and BMI , F(5, 0113) = 276.57, $p<0.001$; partial eta squared = 0.120. An inspection of the means for height, weight and BMI indicated a significant increase from one year group to the next across the age groups (see Figures 1–3).

Discussion

The Macau population has witnessed significant lifestyle changes during the last three decades. Subsequently, physical inactivity, sedentary lifestyle, and an ever-increasing rate of obesity have become prevalent in Macau (Instituto do Desporto do Governo da RAEM, 2015). The current study attempted to identify the BMI patterns among the children

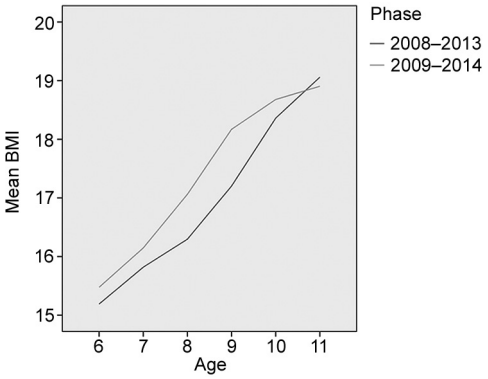

Fig. 4. Mean BMI for the two phases

(male and female), ages 6 to 11 years, in Macau over a period of 7 years in two phases (first phase: 2008 to 2013 and second phase: 2009 to 2014), with students recruited from ten schools in the city. One of the purposes of the study was to learn about the BMI level and patterns of Underweight, Standard, Overweight and Obesity, between male and female students in different age periods.

The use of BMI to measure overweight or obesity follows the rules of using height and weight as determinant factors. This method is widely adopted as a popular measuring tool in observing the rate of obesity, lifestyle development, health habits in people with an obesity problem and active living over the last thirty years due to its easy and inexpensive nature. The study showed a significant increase in height, weight and BMI from one year group to the next across the age groups from 6–11 years. Overweight or obesity is easily observed when there is an increase in weight without an increase of height, a higher obesity weight in return. When this understanding is applied to the current study, the male students were significantly heavier than the female students of the same age over the six years of observation. Thus, male students from ages 6 to 11 years (2008 to 2013) had significantly higher BMI levels than their female counterparts of the same age. In the second phase (2009–2014) of the study, students' heights indicated that there was not much difference between the two gender groups. At age 7, the boys are slightly taller than the girls, but the girls are slightly taller than the boys at age 10. The results of the two phases (2008 to 2014 and 2009 to 2014) revealed that when students' heights was observed, there was not much difference between the same gender group (male and male) but if there is an increase of weight, a difference is observed. This is the case with this study, that at ages 6, 7, and 10 years old, boys of the second phase (2009 to 2014) are slightly taller than the boys of the first phase (2008–2013) of the same ages. The effect size, however, was very small, indicating that the difference does not have much practical value. When the weight of the students is considered for the first phase (2008–2013), the male students were significantly heavier than the female students of the same age over the six years of observation. Furthermore, the male students at ages 6, 7, 8 and 11 years old (2009 to 2014) had significantly higher weight than their female counterparts of the same age.

As the weight and height indicated a different pattern, male students in the first phase (2008–2013) of the study showed a higher BMI level than the female students across all age groups (2008 $t = 5.24$, 2009 $t = 88.25$, 2010 $t = 11.32$, 2011 $t = 17.45$, 2012 $t = 19.70$ and 2013 $t = 19.92$), indicating that 24.2% (Overweight 12.1% + Obese 12.1%) of students in the male sample were categorized as either overweight or obese compared to 17.1% (Overweight

Table 5. Year-wise categorization on BMI level between male and female, 2008 to 2013 and 2009 to 2014

2008 to 2013

Year	Count, %	Male					Female					Total				
		BMI Categories					BMI Categories					BMI Categories				
		U	S	Ov	O		U	S	Ov	O		U	S	Ov	O	Total
2008	Count	143	326	49	38	556	113	182	29	14	338	256	508	78	52	894
	% within	25.7%	58.6%	8.8%	6.8%	100.0%	33.4%	53.8%	8.6%	4.1%	100.0%	28.6%	56.8%	8.7%	5.8%	100.0%
2009	Count	219	251	55	44	569	116	160	39	13	328	335	411	94	57	897
	% within	38.5%	44.1%	9.7%	7.7%	100.0%	35.4%	48.8%	11.9%	4.0%	100.0%	37.3%	45.8%	10.5%	6.4%	100.0%
2010	Count	246	240	59	49	594	96	188	23	23	330	342	428	82	72	924
	% within	41.4%	40.4%	9.9%	8.2%	100.0%	29.1%	57.0%	7.0%	7.0%	100.0%	37.0%	46.3%	8.9%	7.8%	100.0%
2011	Count	142	293	82	94	611	85	191	38	24	338	227	484	120	118	949
	% within	23.2%	48.0%	13.4%	15.4%	100.0%	25.1%	56.5%	11.2%	7.1%	100.0%	23.9%	51.0%	12.6%	12.4%	100.0%
2012	Count	103	247	79	96	525	94	173	40	26	333	197	420	119	122	858
	% within	19.6%	47.0%	15.0%	18.3%	100.0%	28.2%	52.0%	12.0%	7.8%	100.0%	23.0%	49.0%	13.9%	14.2%	100.0%
2013	Count	91	251	83	87	512	55	206	39	34	334	146	457	122	121	846
	% within	17.8%	49.0%	16.2%	17.0%	100.0%	16.5%	61.7%	11.7%	10.2%	100.0%	17.3%	54.0%	14.4%	14.3%	100.0%
Total	Count	1359	3952	861	798	6970	769	2365	432	309	3875	2128	6317	1293	1107	10845
	% within	19.5%	56.7%	12.4%	11.4%	100.0%	19.8%	61.0%	11.1%	8.0%	100.0%	19.6%	58.2%	11.9%	10.2%	100.0%

2009 to 2014															
Year	Count, %	Male					Female					Total				
		BMI Categories					BMI Categories					BMI Categories				
		U	S	Ov	O		U	S	Ov	O		U	S	Ov	O	Total
2009	Count	142	532	95	62	831	78	350	49	31	508	220	882	144	93	1339
	% within	17.1%	64.0%	11.4%	7.5%	100.0%	15.4%	68.9%	9.6%	6.1%	100.0%	16.4%	65.9%	10.8%	6.9%	100.0%
2010	Count	54	377	68	51	550	27	180	34	28	269	81	557	102	79	819
	% within	9.8%	68.5%	12.4%	9.3%	100.0%	10.0%	66.9%	12.6%	10.4%	100.0%	9.9%	68.0%	12.5%	9.6%	100.0%
2011	Count	54	334	78	72	538	19	184	41	30	274	73	518	119	102	812
	% within	10.0%	62.1%	14.5%	13.4%	100.0%	6.9%	67.2%	15.0%	10.9%	100.0%	9.0%	63.8%	14.7%	12.6%	100.0%
2012	Count	37	379	76	65	557	23	173	38	36	270	60	552	114	101	827
	% within	6.6%	68.0%	13.6%	11.7%	100.0%	8.5%	64.1%	14.1%	13.3%	100.0%	7.3%	66.7%	13.8%	12.2%	100.0%
2013	Count	82	365	62	52	561	36	180	28	27	271	118	545	90	79	832
	% within	14.6%	65.1%	11.1%	9.3%	100.0%	13.3%	66.4%	10.3%	10.0%	100.0%	14.2%	65.5%	10.8%	9.5%	100.0%
2014	Count	46	357	75	88	566	27	198	34	23	282	73	555	109	111	848
	% within	8.1%	63.1%	13.3%	15.5%	100.0%	9.6%	70.2%	12.1%	8.2%	100.0%	8.6%	65.4%	12.9%	13.1%	100.0%
Total	Count	1359	3952	861	798	6970	769	2365	432	309	3875	2128	6317	1293	1107	10845
	% within	19.5%	56.7%	12.4%	11.4%	100.0%	19.8%	61.0%	11.1%	8.0%	100.0%	19.6%	58.2%	11.9%	10.2%	100.0%

1st Note: U – Underweight, S – Standard, Ov – Overweight, and O – Obesity.
2nd Note: Percentage appears in parentheses below counts (Male BMI, 2008 to 2013).
χ^2 (n = 3368) = 203.532, $p < 0.05$.
Note: Percentage appears in parentheses below counts (Female BMI, 2008 to 2013).
χ^2 (n = 2001) = 53.841, $p < 0.05$.
Note: Percentage appears in parentheses below counts (Male BMI, 2009 to 2014).
χ^2 (n = 6970) = 645.346, $p < 0.05$.
Note: Percentage appears in parentheses below counts (Female BMI, 2009 to 2014).
χ^2 (n = 3875) = 77.

10.4% + Obese 6.7%) of students in the female sample. The overall rate showed that 20.7% (Overweight 22.2% + Obese 18.8%) of the students over the six-year period of observation were either overweight or obese. In the second phase (2009–2014) of the study, a higher BMI level was found among the male students than the female students across all age groups (2009 t = 2.68, 2010 t =2.886, 2011 t = 3.076, 2013 t =4.228, and 2014 t = 2.405). Additionally, the findings showed that 23.8% (Overweight 12.4% + Obese 11.4%) of students in the male sample were categorized as either overweight or obese compared to 19.1% (Overweight 11.1% + Obese 8.0%) of students in the female sample. The overall rate showed that 41% (Overweight 23.4% + Obese 19.4%) of students were either overweight or obese, which is consistent with findings from Pan et al. (2009) and Wang et al. (2002).

Results of the two phases (2008 to 2014 and 2009 to 2014) revealed that male students in 2008 had a higher BMI level than in 2009 in the two age categories (8 years t=3.025 and 11 years t=3.377). In the comparison of the two phases (2008–2013 and 2009–2014) between common gender and gender-based, the results showed an interesting outcome for common gender (BMI, male between male students), indicating that 48% of subjects were either overweight or obese (first phase + second phase: (Overweight 12.1% + 12.4%) + (Obese 12.1% + 11.4%)). In the same comparison for females between the two Phases (2008–2013 and 2009–2014), the results showed a higher BMI level (9 years, t=3.151) and that 42.3% were either overweight or obese (first phase + second phase: 36.2 (Overweight 10.4% + 11.1%) + (Obese 6.7% + 8.0%)).

Such differences of BMI pattern between male and female students are also seen in other studies. For example, a similar pattern of observation was found in other studies. Qiu, Guo, Duan, Yang, and Sakamoto (2013) carried out a study on BMI for children ages 6 to 18 years in Beijing, China. The results indicated that BMI curves differed for boys and girls. The BMI curves for urban children were also higher than rural children at the upper percentile. The results from this study showed that Beijing BMI curves were higher than that of the Chinese national level. Beijing boys had higher BMIs in medium (6.5–14 years) and upper percentiles and lower BMIs in lower percentiles than WHO and other references. Beijing girls had lower BMIs in medium and lower percentiles but higher BMIs compared to the WHO reference before age 15.5 years in the upper percentiles. Lifoter et al. (2014) conducted a study to examine the relationship between height for age with three measures of adiposity in 2298 Caucasian children (1251 boys) aged 4–14 years. The results of the study showed a significant increasing trend in mean SDSs for BMI, body fat % and waist circumference (WC) with increasing height standard deviation scores (SDS) in overweight/obese children only. A higher prevalence of excess weight, measured by BMI SDS among children taller for their age, is replicated when using % BF and WC. The height-for-age measurement has potential in screening children for later risks of obesity.

Nevertheless, the reason of this differences may be the result of the different activities pattern between boys and girls and this is the fact that researchers need to be careful. Hao et al. (2015) investigated gender differences in physical fitness indexes in relation to BMI lev-

els among Inner Mongolia medical students in China. The results of the study showed that male students may be likely to spend more time using computers than female students, reducing their time spent participating in physical activities. Nevertheless, there is no conclusive results to this observation as for example in Santaliestra-Pasías et al. (2015) discussion, dietary patterns, physical activity and sedentary behaviours are some of the main behavioural determinants of obesity. The sexual maturation could be another reason for the high level of BMI among male students. Nevertheless, this suggestion was challenged as in Wang (2002)'s study that early sexual maturation was positively associated with excess weight and obesity in girls, but the association was reversed for boys. Nevertheless, in this study, it has a different pattern with higher BMI in male students than female students.

Conclusion

Fighting epidemic obesity is one of the principal goals of UNESCO, the WHO and other health-related organizations working at the international level. A huge gap has been recognized in comparing the WHO recommendations for physical activity norms and the data received worldwide. The current study conducted over 10 years in two phases (first phase, 2008 to 2013 and second phase, 2009 to 2014) has provided a solid foundation in order to identify BMI status among Macau students and also immensely helpful to conduct a gender-based analysis on the BMI categories. This attempt would certainly beneficial in order to provide information to the Ministry of Education, Macau at the same time imbedded substantial strategies how to implement and follow the recommendations extended by the WHO related to overweight and obesity.

Male students were identified as having significantly higher BMIs compared with their female counterparts in the two phases. Common gender (male to male) and gender-based (male to female) analyses were conducted between the two phases, and interestingly, across all age categories, significant differences were observed in the students' BMI status. Surprisingly, in the second phase (2009–2014), the mean BMI is higher compared to the first phase (2008–2013). From the analyses, we can predict that overweight and obesity will continue to increase over time. In developed countries, socio-economic status has been inversely associated with obesity, with only a few exceptions, regardless of the socio-economic status measures utilized: income, education and occupation. The need for different activity levels for boys and girls seems to be the message in the Sarkin, Mckenzie and Sallis (1997) and Jandric (2010) studies. For example, the Sarkin et al. (1997) study observed different activity levels in boys and girls during physical education lessons and recess periods. Boys were significantly more active than girls during recess periods, and girls were significantly more active during physical education lessons than at recess period. The Jandric (2010) study indicated the differences between boys and girls in activity level. Determining the different contributors to this pattern is an issue that requires further discussion. In fact, maintaining the obesity rate at a reasonable level in boys and girls and establishing effective measures to prevent excessive increases in BMI are important goals because once overweight has been reached, it becomes difficult to reverse

the situation. This effect applies to both genders.

Limitation of the study

The limitations of the present study should be mentioned. There was no information on longitudinal growth because of the cross-sectional study design. Further prospective cohort studies or replicated cross-sectional studies will be required to evaluate the impact of the cohort effect on growth patterns in children.

Recommendations

Participation in a regular physical activity programme is highly recommended by the World Health Organization to maintain health and fitness. However, the present study has generated some information that has value as a reference and can be used as a foundation for policy development in Macao and other Asian countries. Changing the behaviours of individuals as well as diet and exercise patterns are pressing issues that have been on researchers' agendas worldwide. Nevertheless, these initiatives and strategies need to be implemented with suitable formats and delivered at the appropriate time to create the necessary impact on groups with different needs. The concept of maintaining a balanced BMI status among children is heavily relied on their previous patterns of behaviour. Recently, López Sánchez and Díaz Suárez (2017) conducted a study to analyse the level of habitual physical activity among adolescents from India and Spain through Physician-based Assessment and Counseling for Exercise (PACE). Two questions were asked, including how many days in the last week (PACE 1) and how many days in a typical week (PACE 2) a subject performs at least 60 minutes of physical activity. The results showed that 13-year-old adolescents from Spain and India do not complete enough physical activity according to the recommendations of the WHO. Additionally, 80.5% of the Spanish adolescents and 76% of the Indian adolescents of the sample were inactive according to the classifications of the PACE questionnaire. Therefore, these results clearly demonstrate the pandemic spread of obesity in developing and developed countries. Therefore, since Macau is one of these developed countries, the initiation of a programme such as 'Shop with Your Doc', which was recently initiated by a network of hospitals in the US State of California and involves stationing doctors and nutritionists in supermarkets to help customers navigate food choices, is highly recommended. Parents typically want their children to be healthy and appropriate nourished. However, the supermarket dilemma is all too common, with consumers questioning: is this item healthy? Fattening? Is there a substitute? These circumstances represent times when many consumers wish that they had a specialist at their side. This is especially common during the holiday season, when people tend to avoid any dietary caution. Valuable advice is available through the 'Shop with Your Doc' programme to shoppers making their way down aisles crammed with mouthwatering temptations, many of which are processed and packaged (China Daily 2016). Additionally, the childhood period is critical in the prediction of healthy adolescence and adulthood. Therefore, children should be considered the priority population for intervention strategies. Prevention may be achieved through a variety of interventions that

target built environments, physical activity, and diet. Nearly all researchers agree that prevention could be the key strategy for controlling the current epidemic of obesity so that children can have a healthier transition into adolescence and adulthood. Attention is especially required when students reach the ages of 9 to 10 years because children can easily develop weight and obesity problems at this time. Raising levels of activity and participation in sports will not only reduce economic costs but can also result in a range of social and community benefits, including reduced anti-social behaviours, improved educational attainment and the establishment of community cohesion (CSJ Sport Working Group 2011). Nevertheless, it is important for the planner to implement the appropriate activities at a suitable time. Almost all researchers agree that prevention could also be the key strategy for controlling the current epidemic of obesity. Therefore, it is highly recommended that BMI-for-age should be used to routinely screen for overweight in adolescents and other age group populations (Himes and Dietz, 1994). In addition to this recommendation, special attention must be given to male students' activity levels in physical education and sport activities.

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Authors' contributions

All the authors participated in the study design, data analysis and the writing of the manuscript.

Conflict of interest

There is no conflict of interests regarding publication of this article.

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