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博　士　論　文

The comparison of ambulatory activity among people living in different regions, and relationship with BMI in Pohnpei state, the Federated States of Micronesia: Cross-sectional study

(ミクロネシア連邦ポンペイ州における異なる地域に住む人々の歩行活動および BMI との関連についての比較：横断的研究)

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Abstract

Aims: To clarify people's ambulatory activity and the relationship with BMI among people living in different regions with different lifestyles within the Federated States of Micronesia (FSM), where has been experiencing a rapid increase in the obesity population. This study is the first study which quantitatively explores physical activity in the country.

Methods: A cross-sectional study was conducted from July to September in 2019. 50 participants were recruited from Kolonia (urban area in a main island) and Mand (rural area in the main island), and 2 participants in Kolonia dropped out, while 34 participants were recruited in Pingelap (outer island). BMI was calculated based on anthropometric measurements. Ambulatory activity was measurement by pedometer-determined steps/day.

Results: Average steps/day varied among the three regions (4179 to 7282 to 9252 in males, 3714 to 5087 to 8069 in females, Kolonia to Mand to Pingelap, respectively, $P<0.001$). A linear mixed model showed a statistically inverse correlation with steps/day after adjustment of the differences in the relationship of each region ($\beta=-0.436$, 95% CI =-0.814 to -0.052).

Conclusion: Urbanization might decrease ambulatory activity within FSM. Increasing ambulatory activity can decrease BMI, which might be one of the clues to solve the increasing prevalence of obesity.

1. Introduction

Today, overweight and obesity are serious health concerns worldwide. Obesity, which is fundamentally considered a result of energy imbalance between calories consumed and calories expended, is one of the main factors of non-communicable diseases (NCDs), which kill 41million people each year and accounts for 71% of all deaths in the world (WHO, 2018a, 2020). The rise of obesity population was considered as an issue only in developed countries at past. However, today, developing countries are also facing a rapid increase in the prevalence of obesity (Caballero, 2007).

Socio-economic development and urbanization have been playing a significant role in the increasing of obese population by the nutrition transition. The nutrition transition is a concept of dynamic shifts in dietary intake and physical activity: the consumption of fat and sugar in diet has increased due to reduced prices of high-energy-density foods instead of traditional food, and the physical activity has declined by introducing new technology

(Popkin, 1999, 2001). The dynamic shift in physical activity from moderate or vigorous level to mild or sedentary level occurred in occupational, domestic and travel settings, at the same time with the increase of ownership of TV, cooking tools and motorized vehicles (Popkin, 1999, 2001; Bell et al., 2002; Dennison et al., 2002; Monda et al., 2007, 2008) and researchers found that this trend related to weight gain (Bell et al., 2001, 2002; Dennison et al., 2002; Monda et al., 2008).

Federated States of Micronesia (FSM) is one of the countries located in the Pacific. FSM has been facing a rapid increase in the obese population. According to the World Health Organization, 36% of adult males and 47% of adult females were obese in 2016 (WHO, 2018b). The mortality by NCDs in FSM is relatively higher than other countries with the same development level because of the high prevalence of obesity (WHO Western Pacific Region, 2012).

Same as other developing countries, socio-economic development and urbanization have been considered as one of the main drivers of the increase of obesity in FSM. FSM had experienced long term colonization until the independence in 1986 after governance by Spain, Germany, Japan, and the United States. There was a complete shift to the new cash-based economy between 1960 and 1990 with dramatic increasing subsidies from the United States. The new-cash based economy forced people to change the method of food security from agriculture, fishing and gathering to purchasing. They no longer collect firewood due to the introduction of propane stoves. Moreover, the employment policy of the United States made people start having sedentary jobs. During the span, ownership of motor vehicles also increased due to the construction of a peripheral road in Pohnpei island by Japanese aid (Francis and Hazel, 2004; Cassels, 2006; Mizumoto, 2016). As a result of this phenomenon, peoples' physical activity seems to decrease in this period. Previous studies pointed out that the physical inactivity and unhealthy diet are the main causes of the high prevalence of obesity (Englberger et al., 2003; Francis and Hazel, 2004; Cassels, 2006; Mizumoto, 2016).

There are various methods to explore physical activity. Especially pedometers and accelerometers have been widely used to objectively monitor physical activity with an increase in their introduction in the market. The pedometer is a device to measure steps in walking or running, whereas the accelerometers measure the 3-dimensional accelerations of movements, which reflect the frequency, duration, and intensity of physical activity in individuals. Although the accelerometer can provide more detailed information, the pedometer is more likely to be used in a field of clinical and public health because of its simplicity, reasonable cost, and a user-friendly output (Tudor-Locke et al., 2002; Barreira et al., 2013; Hu, 2013). In the last two decades, studies explored physical activity by pedometer-determined ambulatory activity has been accumulated in many countries (Moreau et al., 2001; Thompson et al., 2004; Tudor-Locke and Bassett, 2004; Chan et al., 2004; Hornbuckle et al., 2005; Hemmingsson and Ekelund, 2007; Clemes et al., 2008; Cook et al., 2008; Schmidt et al., 2009; Bassett et al., 2010; Mitsui et al., 2010; O. Ferdinand et al., 2012; Owłasiuk et al., 2014; Pillay et al., 2015; Yuenyongchaiwat et al., 2017), and several studies have found an inverse relationships between steps/day and BMI (Thompson et al., 2004; Hornbuckle et al., 2005; Hemmingsson and Ekelund, 2007; Clemes et al., 2008; Cook et al., 2008; Bassett et al., 2010; Mitsui et al., 2010; O. Ferdinand et al., 2012; Owłasiuk et al., 2014; Pillay et al., 2015). However, there have been concerns regarding the use of pedometers in the overweight or obese population. Melanson et al. (2004) suggested that obese and especially older individuals tended to ambulate at slower walking speeds, and it led to undercounting steps. Also, Shephed et al. (1999) found that a pedometer had 5.6% more overall error than the step activity monitor in the obese subjects (BMI>30 kg/m^2), while only 1.0% more overall error in the non-obese subjects (BMI<30 kg/m^2). On the other hand, Feito et al. (2012) demonstrated that BMI had no effect on step count accuracy of a pedometer both on the treadmill walking condition and free-living environment. Swarts et al. (2003) also showed that a pedometer accurately counted steps at speeds above 80m×min^{-1} even in overweight and obese samples. They also stated that pedometers could be useful for observational studies. In addition, a study which compared steps/day counted by an accelerometer and a pedometer in a free-living sample of overweight and obese adults found a high correlation between outputs of these devices, while posing a caution when directly comparing or using their output interchangeably (Barreira et al. 2013). These findings support that pedometers could count accurately in the overweight and obese population, so pedometers might be appropriate devices to evaluate the relative quantity of physical activity in population having high prevalence of overweight and obesity.

To our knowledge, no study has reported on the ambulatory activity and relationship with BMI in the FSM. Not only ambulatory activity, although physical inactivity has been pointed out as one of the causes of obesity, quantitative data related to any physical activity has also yet to be explored in the country. Thus, no data could support that physical inactivity is a cause of obesity. Therefore, this study aims to investigate ambulatory activity as an assessment of physical activity by using pedometers, and its relationship with BMI. We hypothesize that ambulatory activity might be influenced by people's livings environment, thus we conducted data collection in different regions within the country. This study would provide insight into physical activity and its effect on obesity in the FSM.

2. Materials and Method

2.1 Study site

FSM consists of four states; Yap, Chuuk, Pohnpei, and Kosrae. This study was conducted in Pohnpei state, where the capital of FSM is located. Pohnpei state has one main island of Pohnpei island and five small outer islands. We chose two study sites from Pohnpei island, Kolonia, which is a center of economics and the biggest town in Pohnpei island, Mand, which is a small community located in rural municipality. We also conducted this research in one of the outer islands of Pingelap island, which is roughly 250 km away from Pohnpei island. Pingelap island is one of islets of Pingelap atoll. Pingelap atoll consists of three islets including Pingelap island, but only Pingelap island is inhabited. The area of Pingelap atoll is 1.8 km^2. As a supplemental explanation, Mand is a community where people who are originally from Pingelap island settled in. According to the latest census which was conducted in 2010, the number of household and population of these study sites were 1,148 and 6,074 in Kolonia, 81 and 459 in Mand and 71 and 258 in Pingelap, respectively (FSM Statistics, 2020).

2.2 Data collection

Data collection was conducted from July to September 2019. 50 participants enrolled in this study in Kolonia and Mand, while 34 participants enrolled in Pingelap due to a logistic reason. The participants were recruited in different methods in different regions because independent sampling from an ongoing survey in Kolonia was not allowed: In Kolonia, the participants were randomly recruited by simple random sampling for the survey which was carried out by the Department of Public Health in Pohnpei state, then among all participants, 50 individuals were arbitrarily selected for this study. We also used data of anthropometric measurements of the survey regarding the participants in Kolonia. In Mand and Pingelap, at first 50 and 34 households were selected and then one of the family members was selected by using simple random sampling. Two of the participants in Kolonia dropped out because their pedometer was broken during the survey. For this data collection, research assistants who were fluent in both English and local language were recruited at each study site. Demographic information was obtained by face to face interview using a questionnaire.

Height was measured without shoes to the first decimal in cm, using a portable stadiometer (SECA213, SECA, Japan). Weight was also measured without shoes by a digital scale (BC-751, Tanita, Japan) to the first decimal in kg. As mentioned above, different digital scale and stadiometer were used in Kolonia, but accuracy was confirmed. BMI is widely used to classify overweight and obesity in adults. It was computed as weight (in kg) /squared height (in meter). For adults, BMIs equal or over 25 kg/m^2 and equal or over 30 kg/m^2 are regarded as overweight and obese, respectively (WHO, 2020).

Participants were asked to wear the pedometer (HJA-405T, Omron, Japan) for consecutive three days except during sleeping, bathing, and swimming.

Twenty-four hours dietary recall was conducted to estimate energy intake for a single day with Automated Multiple-Pass Method, which was developed by the US Department of Agriculture to collect dietary data in the National Health and Nutrition Examination Survey (FAO, 2018). After collecting the data from 24 hours dietary recall, total energy intake (MJ) was calculated by using The Pacific Islands food composition tables second edition (FAO, 2004) and USDA Food Composition Database (USDA, 2020).

2.3 Data treatment and statistical analysis

The correctness of data entry to computer was confirmed by triple entry. One-way ANOVA was used to compare the result of anthropometric measurement, physical activity (steps/day), and energy intake among three different regions for both genders separately. The relationship between the number of steps per day and BMI was examined using Pearson's product-moment correlation coefficient. A linear mixed model was applied to explain the variance of BMI by the number of steps per day as fixed effect, the region as giving random effect, and the age, gender, and energy intake as covariates. When applying the linear mixed model, the unit of steps/day was shown as 1000 steps/day to make the values of coefficient easier to see. All analyses were performed with R, version 3.6.3 (R Core Team, 2020). The significance level was set at 0.05.

Ethical approval

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving study participants were approved by the ethical committee of the Graduate School of International Cooperation Studies of Kobe university and the Department of Health and Social Affairs in Pohnpei state. Written informed consent was obtained from all participants.

3. Result

Table 1 shows demographic information about the participants. Of the 132 participants, 57 were males (Kolonia: 20, Mand: 19, Pingelap: 18) and 75 were females (Kolonia: 28, Mand: 31, Pingelap: 16). The means and standard deviations of age were 42.2±14.28 in Kolonia, 39.5±15.08 in Mand, and 45.7±15.02 in Pingelap, respectively. In Kolonia, 83.3% of participants were Pohnpeian, but nearly 100% of participants in Mand and Pingelap were Pingelapese. All participants completed elementary school. Regarding employment status 52.1% in Kolonia, 40.0% in Mand, and 41.2% of participants in Pingelap were employed.

The result of anthropometric measurement is shown in Table 2. The mean BMI did not differ statistically among males but they were all higher than 25 kg/m^2, which is regarded as overweight. On the other hand, the mean BMI of females had a significant regional difference ($P<0.001$) and the mean BMI of Mand and Pingelap were higher than 30kg/m^2, which are regarded as obesity.

Table 3 demonstrates the mean and standard deviation of steps/day. The mean steps/day statistically differed among regions for both genders ($P<0.001$). In every region, male had higher ambulatory activity that females. The mean energy intakes were 10.5±4.50 MJ for males and 7.7±3.36 MJ for females in Kolonia, 8.6 ±3.64 MJ for males and 7.9±2.60 MJ for females in Mand, and 7.0±1.89 MJ for males and 7.5±2.28 MJ for females in Pingelap. There was a significant regional difference in mean energy intake for males ($P=0.03$).

Table 4 summarizes the result of correlation analysis by Pearson product-moment correlation coefficient. BMI of males in every region and females in Kolonia and Mand tended to inversely correlate with steps/day. However, statistical significance was only seen in Kolonia females ($r=-0.467$, $P=0.01$). Figure 1 and Figure 2 presents the 80% probability ellipse for the relationship between steps/day and BMI for males and for females, respectively. Although females in Mand showed tendency of inverse correlation between steps/day and BMI by Pearson product-moment correlation coefficient, the figure 2 did not show correlation compared to males and females in Kolonia. From the result, it is clear that the relationships between BMI and steps/day was different by region in either gender. The result of the linear mixed model was summarized in Table 5. Steps/day had significant negative effect on BMI. The result suggested that the increase of 1000 steps/day decreased BMI by 0.436 kg/m^2. The result also showed that female gender positively correlated with BMI and females had higher BMI than males by 4.656 kg/m^2. Age and energy intake did not correlate with BMI in this study.

4. Discussion

4.1 Regional difference in ambulatory activity

This is the first study to examine the difference in ambulatory activity among different regions within FSM. Regardless of gender, the mean steps/day was lowest in Kolonia (4179 in males and 3714 in females) and highest in Pingelap (9252 in males and 8069 in females). This result might reflect the difference in the living environment among regions. People living in Kolonia, where is the most urbanized, normally own their cars and they drive when they go neighborhood. Kolonia is also the place where office job opportunities are concentrated, thus physical activity in traveling and occupational activity might be lower. On the other hand, transportation is almost limited to be on foot in Pingelap because the island is relatively small. Also, people still have a custom to go to taro patches and they do housework without electronic machines. A previous study targeted a dozen of selected household members reported that less than 10% of participants owned refrigerators in Pingelap, while nearly 60% of participants owned them in Pohnpei (Kawai et al., 2010). They also normally go to sea and jungle or climb coconut trees to obtain foods, thus this traditional lifestyle might increase their ambulatory activity. In Mand, most of the participants who answered as employed commute to Kolonia by cars, whereas half of the participants do not have a job and they might stay in the community, in which transportation is only on foot. Mand does not have direct access to the sea, so people did not fish or swim. However, some villagers did housework without electronic machines, and thus it is reasonable that the number of steps/days was in the middle of Kolonia and Pingelap (7289 in males and 5087 in females). The national nutrition survey for the Federated States of Micronesia which was conducted in 1987-1988 stated that physical activity was high in remote island and low in urban area in main island (Elymore et al., 1989), which consistent with the result, thus it is considerable that the difference in physical activity level among different regions has not changed for about three decades. This result also suggested that people living more urbanized had lower ambulatory activity.

4.2 Relationship between ambulatory activity and BMI

This study also explored the relationship between steps/day and BMI. As the result, only Kolonia females showed significant inverse relationships. This result was consistent with previous researches explored the relationship in Middle-aged American women (Thompson et al., 2004) and African American (Hornbuckle et al., 2005), South African living in both rural area (Cook et al., 2008) and employed workers in South Africa (Pillay et al., 2015), males office workers living in a rural town in Northern Japan (Mitsui et al., 2010) and African American and Caucasian (O. Ferdinand et al., 2012). Although, the correlation was not statistically significant, males of all regions and Mand females had similar tendencies regarding the relationship.

However, Pingelap females did not show such tendency. In addition, they had the highest BMI even though their steps/day was the highest among females. This result was inconsistent with the previous studies which suggested that people who had higher BMI had lower steps per day. Hemmingsson and Ekelund (2007) compared physical activity between the obese sample (mean BMI was 42.7±6.1 kg/m^2) and the non-obese sample (BMI was 24.0±3.5 kg/m^2). They found steps/day was significantly lower in the obese population (8933steps/day vs 11671steps/day) and correlation between steps/day and BMI was stronger in the obese population than the non-obese population (r=-0.01 vs r=-0.44). Clemes et al. (2008) compared steps/day among the normal weight sample, overweight sample, and obese sample and they found that the obese sample had the lowest steps/day and the normal weight sample had the highest steps/day (8102 steps/day vs 9095 steps/day vs 10247 steps/day). Compared to steps/day in Pingelap, these results of obese population are similar. Thus, the cause of this relationship was unclear, but the paradoxical relationship between steps/day and BMI of Pingelap females may suggest that they cannot expend energy by ambulatory activity and there might be other physical activity related to energy expenditure. Activities with strong exercise intensity such as swimming and farming could be the possibilities. This study did not explore other activities and energy expenditure. These aspects can serve as another avenue for further study.

The linear mixed model, which took into consideration the difference in the association between steps/day and BMI among regions, showed a negative correlation with steps/day. The result suggested that every 1000 steps/day increase can reduce BMI by 0.436kg/m^2. This number was bigger than a previous study conducted in rural South Africa which resulted in an increase of 5000 steps/day decrease BMI by 1.4 kg/m^2 (Cook et al., 2008).

There are some limitations should be acknowledged in this study. Firstly, the measurement period of steps was relatively shorter compared to previous studies. The difference in steps between weekdays and weekends is unclear. Some previous studies found the difference (Tudor-Locke and Bassett, 2004; Clemes et al., 2008), but others did not (Mitsui et al., 2010; Owłasiuk et al., 2014). However, there is no study compare steps between weekdays and weekend in FSM, so further study should access physical activity at least through a week. Secondly, the reliability of the pedometer which we used in this study has not been evaluated. Hu (2013) stated that different models of pedometers vary widely in reliability and validity. However, as mentioned in the introduction, pedometers are appropriate devices to evaluate the relative quantity of physical activity. In this study, we examine steps/day in the same population group by the same model device. Additionally, the same model device was also used in other studies (Oshima et al. 2019; Shinoya et al. 2019). Therefore, the device could be appropriate for this study purpose. Thirdly, this study showed that people living in Kolonia had the lowest mean BMI for females, even though their steps/day was the smallest. This result was considered to be caused by the difference in measurement tools between Kolonia, and Pingelap and Mand. However, there was no significant difference in BMI among males and there might be no difference in measurement skill of measurers. So, it is considered that the influence of different measurement tools was relatively small. Lastly, the sample size in this study was relatively small, especially in Pingelap. Thus, further study should be conducted with a bigger sample size and a longer measurement period of steps/day, and accelerometers or other devices could provide more detailed information for a better understanding of physical activity in this study population.

In conclusion, there was a regional difference in steps/day and urbanization might decrease ambulatory activity in the study sites. After adjustment of difference in the relationship between steps/day and BMI among three regions, the inverse association between steps/day and BMI was found. This study is a cross-sectional study, so that causal relationship was unknown. However, the result suggested that increasing ambulatory activity can decrease BMI, which might be one of the clues to solve the increasing prevalence of obesity. Females in Pingelap showed a different relationship between steps/day and BMI, and their steps/day and BMI were not consistent. Further study is needed to explore other physical activity and energy expenditure in the sample to fill the gap of the unaccountable relationship.

Conflict on interest

"None"

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Author Contribution

Moeno Sakai: Conceptualization, Methodology, Formal analysis, Investigation, Data Curation, Writing-original draft, Visualization, Project administration and Funding acquisition

Minato Nakazawa: Conceptualization, Methodology, Formal analysis, Writing-Review and Editing and Supervision

Delpihn Abraham: Conceptualization, Methodology, Data Curation, Investigation

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Table 1. Demographic information about sampling

		Kolonia (N=48)		Mand (N=50)		Pingelap (N=34)	
		N	(%)	N	(%)	N	(%)
Gender	Male	20	(41.7)	19	(38.0)	18	(52.9)
	Female	28	(58.3)	31	(62.0)	16	(47.1)
Age	Mean	42.2		39.5		45.7	
	SD	14.28		15.08		15.02	
Ethnicity	Pohnpeian	40	(83.3)	1	(2.0)	0	(0.0)
	Pingelapese	1	(2.1)	48	(96.0)	34	(100.0)
	Others	7	(14.6)	1	(2.0)	0	(0.0)
Marital status	Married	36	(75.0)	36	(72.0)	25	(73.5)
	Single, never married	6	(12.5)	12	(24.0)	4	(11.8)
	Separated of divorced	3	(6.3)	0	(0.0)	0	(0.0)
	Widowed	3	(6.3)	2	(4.0)	5	(14.7)
Family member	1	2	(4.2)	12	(24.0)	3	(8.8)
	2-4	18	(37.5)	32	(64.0)	21	(61.8)
	5-	28	(58.3)	6	(12.0)	10	(29.4)
Education	Elementary school completed	12	(25.0)	16	(32.0)	16	(47.1)
	High school completed	25	(52.1)	16	(32.0)	13	(38.2)
	2-4-year college completed	11	(22.9)	16	(32.0)	5	(14.7)
	Professional (Graduate, postgraduate)	0	(0.0)	2	(4.0)	0	(0.0)
Employment status	Employed	25	(52.1)	20	(40.0)	14	(41.2)
	Student	1	(2.1)	0	(0.0)	0	(0.0)
	Housemaker	7	(14.6)	4	(8.0)	7	(20.6)
	Retired	4	(8.3)	1	(2.0)	4	(11.8)
	Unemployed	11	(22.9)	25	(50.0)	9	(26.5)
Personal income (per 2 weeks)	Less than 25$	22	(45.8)	23	(46.0)	13	(38.2)
	25-100	2	(4.2)	14	(28.0)	15	(44.1)
	100-200	8	(16.7)	8	(16.0)	4	(11.8))
	200-300	4	(8.3)	1	(2.0)	0	(0.0)
	More than 300$	11	(22.9)	3	(6.0)	1	(2.9)
	don’t know	1	(2.1)	1	(2.0)	1	(2.9)

Household income	Less than 25$	7	(14.6)	9	(18.0)	9	(26.5)
(per 2 weeks)	25-100	8	(16.7)	6	(12.0)	4	(11.8)
	100-250$	9	(18.8)	19	(38.0)	7	(20.6)
	250-500	9	(18.8)	10	(20.0)	3	(8.8)
	More than 500$	11	(22.9)	4	(8.0)	9	(26.5)
	don't know	4	(8.3)	2	(4.0)	2	(5.9)

Table 2. The result of anthropometric measurement

		Male			P-value	Female			P-value
		Kolonia (N=20)	Mand (N=19)	Pingelap (N=18)		Kolonia (N=28)	Mand (N=31)	Pingelap (N=16)	
Height (cm)	mean	169.7	160.7	161.7	<0.001	154.6	151.0	149.8	0.02
	SD	7.61	5.03	6.84		5.84	5.39	5.20	
Weight (kg)	mean	84.2	71.4	69.0	0.01	68.0	79.2	82.2	0.03
	SD	16.55	16.07	13.68		20.70	20.03	14.35	
BMI	mean	29.1	27.6	26.2	0.15	28.3	34.5	36.7	0.001
	SD	4.86	6.25	3.98		7.93	7.58	6.41	

Table 3. Average steps per day in three regions

		Male			P-value	Female			P-value
		Kolonia (N=20)	Mand (N=19)	Pingelap (N=18)		Kolonia (N=28)	Mand (N=31)	Pingelap (N=16)	
Steps/day	mean	4179	7282	9252	<0.001	3714	5087	8069	<0.001
	SD	2439.70	4102.98	4825.08		2219.84	3356.89	2728.55	

Table 4. The result of correlation analysis by Pearson product-moment correlation coefficient

Gender	Region	Correlation coefficient	95% confidence interval		P-value
			Lower	Upper	
Male	Kolonia	-0.308	-0.660	0.156	0.19
	Mand	-0.423	-0.736	0.039	0.07
	Pingelap	-0.308	-0.678	0.185	0.21
Female	Kolonia	-0.467	-0.715	-0.114	0.01
	Mand	-0.202	-0.519	0.164	0.28

Pingelap	0.277	-0.254	0.679	0.30

Table 5. The result of the linear mixed model

Dependent variable	Independent variable		Estimate	95% confidence interval		P-value	Squared partial correlation coefficient
				Lower	Upper		
BMI	Age		0.009	-0.079	0.096	0.846	0.002
	Gender	Female	4.656	2.203	7.113	<0.001	0.670
	Step		-0.436	-0.814	-0.052	0.018	0.274
	Energy intake		0.186	-0.158	0.528	0.287	0.055

AIC: 893.9824

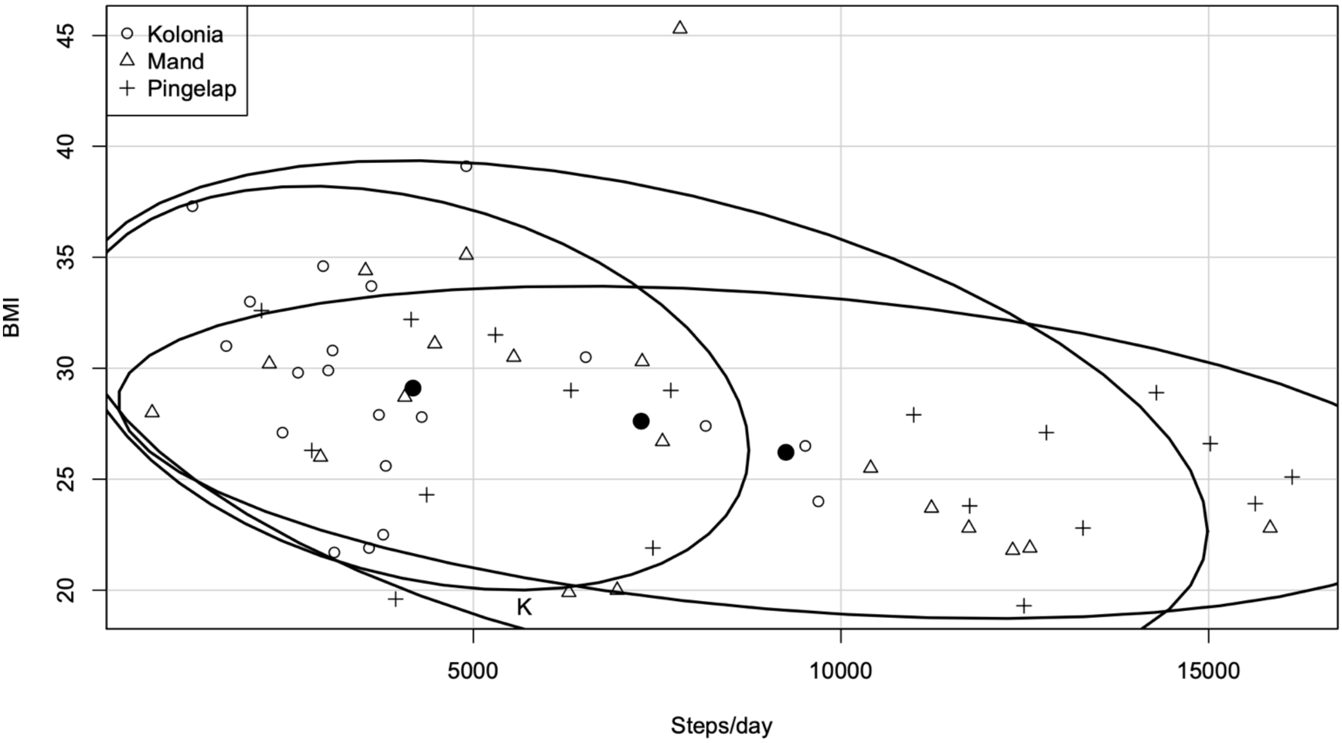

Figure 1. The 80% probability ellipse for the relationship between steps/day and BMI for males

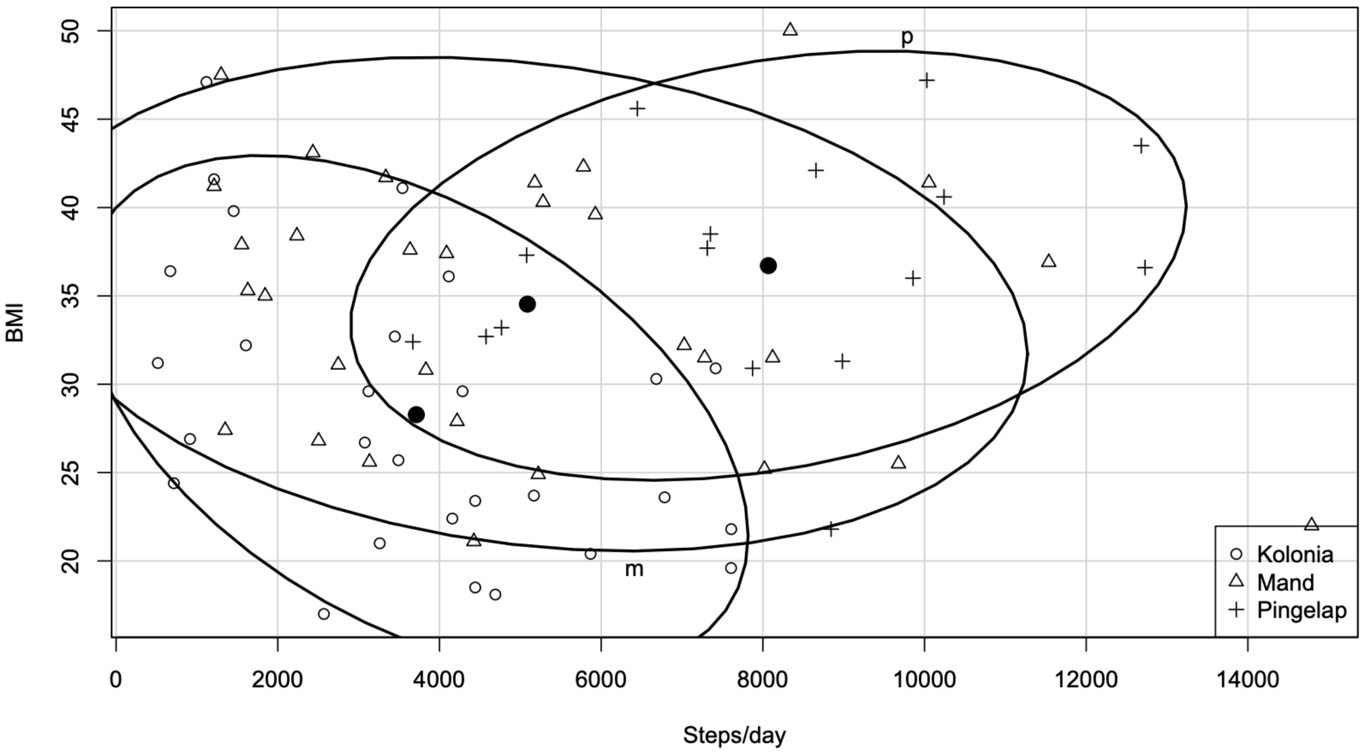

Figure 2. The 80% probability ellipse for the relationship between steps/day and BMI for females