Original Article

Leisure time physical activities and dietary quality of the general and indigenous Taiwanese populations are associated with fat distribution and sarcopenia

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Indigenous peoples are at greater risk of obesity-related health problems for various reasons. These have been explored in the adulthood (≥19 yrs) section of the nationally-representative Nutrition and Health Survey in Taiwan (NAHSIT) for 2005-2008 in Indigenous mountain-dwelling (IndT) (n=226) and general (mainly Han Chinese) (GenT) (n=1486) Taiwanese. Physical activity, BMI, fat distribution (waist circumference (WC) and triceps skinfold (TSF)) and mid arm muscle circumference (MAMC) have been compared. Leisure-time physical activities (LTPA) were assigned metabolic equivalents (METs). Comparisons were made by ethnicity-locality. Indigenous men and women were 3.81 and 5.47 times more obese (WHO criteria BMI ≥30 kg/m^2) than the GenT, respectively. Some 55% of the IndT and 34% of the GenT reported no LTPA. All LTPA types were less evident in the IndT. Multivaiable adjusted ORs (95% CIs) against inactivity as referent were, for sarcopenic MAMC, in Indigenes with MVI-LTPA 0.13 (0.03-0.67) and in the GenT 0.61 (0.37-1.01); in the GenT with LTPA for BMI ≥30 kg/m^2 and obese TSF, they were 0.53 (0.31-0.91) and 0.77 (0.60-0.98), respectively. Without dietary quality adjustment, the sarcopenia risk in GenT with LTPA was significant (OR=0.60, 95% CI: 0.37-0.97). Having adjusted for dietary quality, the significance disappeared. Less sarcopenia was found with ambulation in the GenT (OR=2.07, 95% CI: 1.26-3.43). More over-fatness in an IndT than GenT is associated with less LTPA. LTPA reduces sarcopenic risk irrespective of ethnicity, is partly dependent on diet, and reduces obesity indices in the GenT.

Key Words: obesity, exercise, energy expenditure, body composition, muscle

INTRODUCTION

In Taiwan, mean BMI was greater in rural than in urban and the increase in prevalence of obesity was more rapid in agricultural counties than in cities, constituting an "urban-rural divide".[1,2] Neighbourhoods, aboriginality and socio-economic disadvantage were key factors in explanatory models for obesity in Taiwan.[3] When compared with the Nutrition and Health Survey in Taiwan (NAHSIT) for 1993-1996,[4] that for 2005-2008 shows that both overweight and obesity prevalences for men have increased; and that overweight prevalence for women has decreased by 1%, while that for mild obesity has increased by nearly 3%.[5] The NAHSIT 2005-2008 also reveals that mountainous areas have higher rates of obesity than elsewhere.[5] The consequences of prevalent obesity includes exaggerated cardiovascular (CVD) risk profiles.[6] Nevertheless, there have been non-uniform increases in these morbidity outcomes, with an increased social and economic burden on the health system, and increased mortality.[7,8]

In addition to changing dietary habits in Taiwan,[7] lack of activity is a likely contributor to the changing socio-demography of obesity. Nearly half of the Taiwanese population claim not to engage in any regular leisure time physical activity (LTPA).[9,10] For those who engage in LTPA, the level of activity is less than half that reported in the United States (US).[10] Indigenous Taiwanese who live in the mountainous areas of Taiwan are generally believed to be physically stronger and more adept at sport. But this notion may be questioned since the prevalence of

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Manuscript received 22 May 2013. Initial review completed 6 June 2013. Revision accepted 17 August 2013.
doi: 10.6133/apjcn.2013.22.4.19

obesity is higher in these mountainous areas than in other regions of Taiwan. Systematic analyses of the relationships between physical activity and health among Indigenous people are lacking, especially with regard to possible health enhancement programs.[11,12]

By comparison with Caucasians, in Asian and Indigenous peoples, as in Taiwan, lesser degrees of over-fatness, may lead to adverse health outcomes.[13] It is likely that this is contingent on the accompanying body compositional disorder (BCD) which may reflect compromised socio-ecological circumstances and health-adverse personal behaviours.[14] Some 300,000 Indigenes live in Taiwan, constituting of about 1.3% of the population; most live in the central mountain range, along the east coast or on Lanyu Island (off the south-east coast). With lower living standards, Indigenes may work away from home without their socio-cultural network, while others remain at home where infrastructure may be less developed than elsewhere in Taiwan. Indigenous average life expectancy has gradually increased, but is still 12-13 years below the Taiwanese average.[15,16] There are progressive improvements in social and medical care, national health insurance system delivery and medical service availability.[17]

Indigenous health might be achievable if prevention is the emphasis[18] in communities[19-21] and their households.[22] This would have the potential to address root causes of problems like obesity as a BCD complex which would acknowledge the importance of sarcopenic obesity and that of muscle strength.[23] Further, such advances would take account of the settings which allow these problems with their socio-economic disadvantage and inequity[24] and which are ecosystem-compromised.[24,25] Three behavioural factors are considered to be characteristic and leading contributors to poor health for Indigenous Taiwanese, namely alcohol, betel quid, and cigarette usage, referred to as the 'ABC' of the eco-health problem,[16,26,27] with accidents and injury particularly evident.[15] However, this does not necessarily acknowledge the role of diet and physical activity in the associated BCD or, indeed, that the 'ABC' itself contributes to the BCD.[28-32]

Even though the pathways which connect the environment and community to health outcomes may be complex and mediated only partly via personal behaviours and BCDs,[15,33,34] we have hypothesised that a cross-culturally shared knowledge of physical activity traditions may overcome some of the barriers to better health. We have sought to understand why a tradition of superior athletic achievement among Indigenes does not translate into superior health. In particular, we have asked whether the neglect of community-based traditional exercise habits might be a risk factor for BCDs, not just obesity, and whether cross-cultural opportunities exist to rectify deficits in the physical activity of Indigenous Taiwanese. We have combined representative national nutrition surveys with health-mapping to address these possibilities.

MATERIALS AND METHODS

Study sample

Adults aged 19 years and above (n=4,665) from the NAHSIT 2005-2008 were studied. The 358 townships/ districts in Taiwan were classified into eight strata according to geographical location, population density and dietary pattern. These strata include areas designated as First and Second Northern, Central, Southern Eastern, Hakka, Mountainous, and Penghu Islands. Subjects were randomly selected by a probability proportional to population size sampling method with oversampling of minority groups. They were interviewed by questionnaire and underwent a health examination. The design and sampling for this survey have been described elsewhere.[35] In the present study, we excluded those who did not provide physical activity information, BMI, and those who reported unlikely exercise levels of 35 hours or more per week, leaving 1,712 adults. These comprised of 1,486 general Taiwanese (GenT) and an Indigenous Taiwanese (IndT) population of 226, who were eligible for analysis. The Indigenes were defined by the ethnicity of the father as Indigenous and by living in a Mountainous area (Figure 1). Ethics approval was granted by the Institutional Review Boards of both Academia Sinica and National Health Research Institutes of Taiwan.

Leisure time physical activity (LTPA)

Individual energy expenditures for LTPAs were calculated using metabolic equivalent task scores (METs) from a physical activity frequencies questionnaire. We used the Ainsworth conversion factors to express the various daily physical activities, taking account of perceived breathing intensity, as weekly energy expenditure.[36,37] Exercise types included traditional Chinese exercise, ball games, gymnastics and dance and walking, running and bicycling (the latter 3 referred to collectively as 'ambulation'). We chose moderate to vigorous intensity (MVI) LTPA as our investigatory model with a range of 300-2000 kcal per week.[9,38-41]

Dietary methodology

Dietary Diversity Score (DDS) was used to represent personal dietary quality. A DDS was derived from 24-hour dietary recall. According to the Taiwanese Food Guides,[42] half a serving per day for one of the six food groups (meats, rice and grains, fruits, vegetables, dairy, and fat and oil) was the minimal intake required for a DDS score of one. Thus, the DDS ranged from 0 to 6 where higher scores express better nutrient intake.[43-45]

Covariate measurements

We calculated BMI (in kg/m^2) and, according to the definitions of WHO, obesity was defined as a BMI ≥30. This definition has been used in reference to the Taiwanese population in general for those who are above the level of "moderate obese" because we have taken a particular interest in aboriginal health where there is less certainty about appropriate indicators of body fatness. Abdominal obesity was defined as a waist circumference (WC) ≥90 cm for men or 80 cm for women. Triceps skinfold (TSF) thickness is a measurement of subcutaneous fat where over 18 mm for men and 26 mm for women was defined as obesity. Muscle mass was determined by the mid upper arm where circumference and TSF allowed for its computation as Mid Arm Muscle Circumference (MAMC = MAC – (π *TSF)). We defined sarcopenia as ≤10^{th} percentile of MAMC.[46]

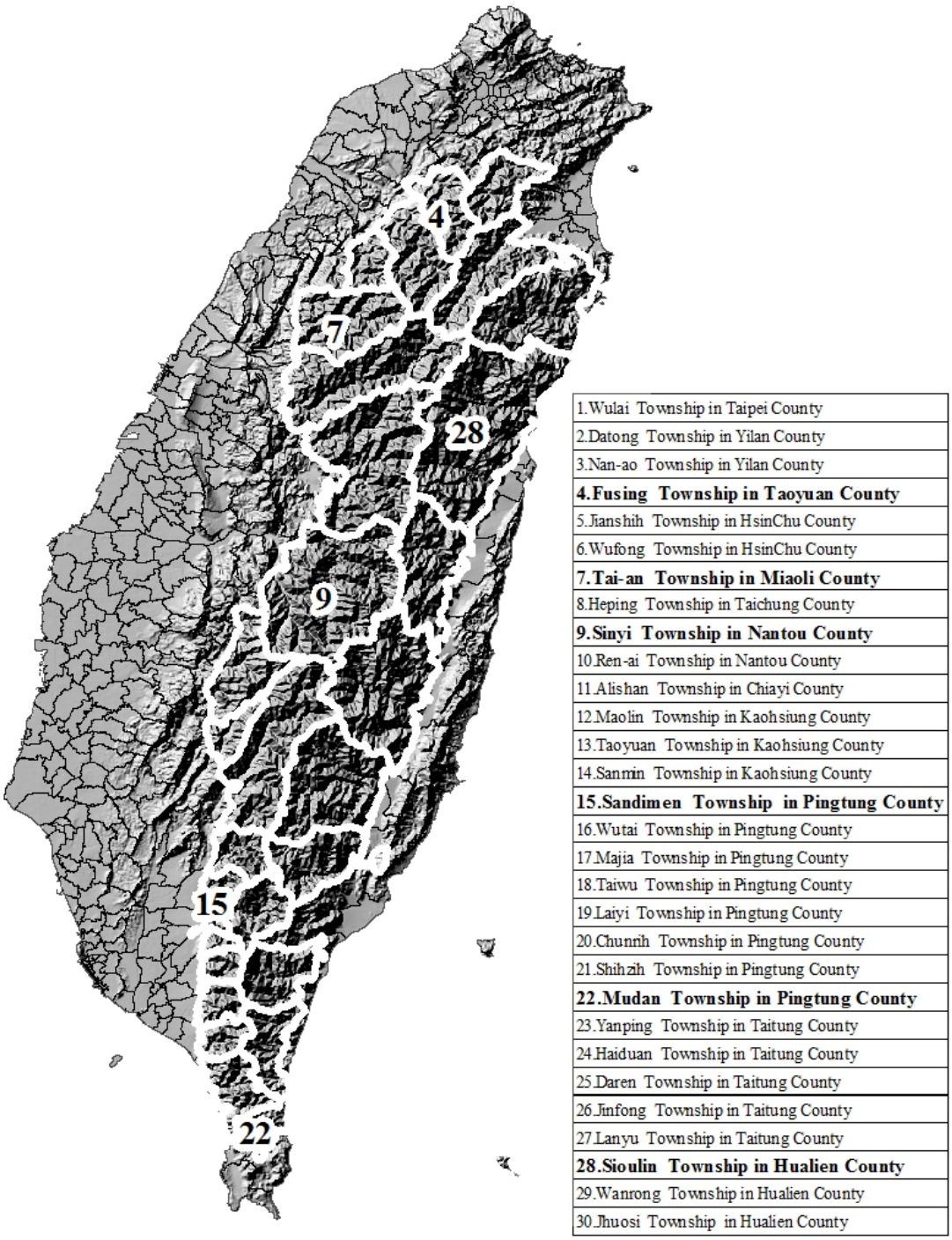


Figure 1. Map of Mountainous areas with sample frame. Mountainous areas in Taiwan numbered 4, 7, 9, 15, 22, and 28 represent the sampling areas for the Nutrition and Health Survey in Taiwan (NAHSIT) 2005-2008.

Statistical analyses

Statistical analyses were performed using SAS for windows version 9.1 and SUDAAN version 8.[47] SUDAAN was used to gain the unbiased standard error. The t-test and chi-square test were used to analyse the population differences with regard to exercise. Multiple logistic regression analyses were used to evaluate the odds ratios (ORs) for obesity between the with-moderate or without LTPA in the Indigenes and the general Taiwanese groups. Models were adjusted for gender, age, education, household income, smoking, drinking alcohol, and betel-nut chewing. $P<0.05$ was considered significant.

RESULTS

Table 1 compares the characteristics between the Indigenes and the general Taiwanese population groups. In each LTPA category, IndT was proportionately less frequently active than was GenT, with the inactive at 54.6% versus 33.8% for men and 52.9% vs 32.8% for women. However, the leisure time energy expenditure (LTEE) was not different. In GenT, they were found for men with adverse socio-economic status in terms of education and income; personal behaviours, such as smoking and DDS. These variables in men cluster with increased appendicular obesity, as judged by TSF. For women in GrnT, for alcohol consumption (with LTPA less frequent), betel-nut

Table 1. Indigenous and general Taiwanese population demographics and personal behaviours with or without leisure-time physical activity (LTPA)

Characteristic	Indigenes (n=226)			General Taiwanese (n=1486)		
	With LTPA		Inactive†	With LTPA		Inactive‡
	With MVI-LTPA	Total		With MVI-LTPA	Total	
Men (age ≥ 19y)						
Number (%)	32 (36.5)	50 (45.4)	55 (54.6)	268 (51.2)	481 (66.2)	244 (33.8)
Age (years)	42.3±1.94	42.9±1.56	39.9±2.12	44.9±0.93	44.4±0.93	42.3±1.22
Educational level						
Primary and below	23.4	25.4	25.6	10.1	10.8*	13.9
Secondary education	38.9	34.6	53.6	22.0	23.2	33.4
University and above	37.8	40.0	20.8	67.9	66.0	52.7
Household income						
<40,000 NTD/month	70.5	61.7	68.1	24.5***	24.5**	39.8
40,000-80,000 NTD/month	13.9	28.7	19.7	35.4	41.5	44.9
>80,000 NTD/month	15.6	9.63	12.3	40.2	34.1	15.3
Smoking (Yes, %)	33.0	33.2	46.0	25.4***	29.7**	49.7
Drinking alcohol (%)						
Yes, with the habit	30.4	23.8	41.1	13.6	13.6	16.7
Yes, without the habit	46.3	40.5	18.2	45.9	47.0	45.1
Never	23.3	35.7	40.7	40.5	39.5	38.2
Betel nut chewing (Yes, %)	41.1	41.6	59.6	7.65*	8.72	15.1
Leisure-time energy expenditure (kcal/week)	952.5±96.0	2823±652	-	1087±35.9	2063±149	-
Weight (kg)	67.8±3.14	69.3±2.64	73.2±2.23	67.4±0.67	68.5±0.47	69.9±1.53
BMI (kg/m^2)	25.3±1.02	26.1±0.94	27.3±0.81	23.8±0.20	24.0±0.13	24.4±0.36
Waist circumference (cm)	85.1±2.46	86.6±2.21	89.8±2.25	83.2±0.61	83.4±0.57	84.5±0.82
TSF (mm)	17.1±3.27	18.9±2.97	21.3±2.21	16.8±0.77***	16.8±0.81***	19.6±1.02
MAMC (cm)	24.6±0.79	24.6±0.96	24.8±0.77	24.1±0.34	24.4±0.37	23.8±0.42
Dietary Diversity Score	4.25±0.34	4.10±0.29	3.94±0.22	4.76±0.08**	4.81±0.08**	4.33±0.13
Women (age ≥ 19y)						
Number (%)	34 (33.0)	60 (47.1)	61 (52.9)	296 (54.8)	493 (67.2)	268 (32.8)
Age (years)	45.1±2.29	43.7±2.52	41.5±2.72	43.3±1.25	43.7±0.84	42.2±1.11
Educational level						
Primary and below	37.5	42.3	44.6	24.0	22.8	25.4
Secondary education	32.1	29.3	28.2	19.6	20.9	25.3
University and above	30.4	28.5	27.2	56.4	56.3	49.3
Household income						
<40,000 NTD/month	65.2	73.2	77.7	33.0	29.8	33.2
40,000-80,000 NTD/month	34.8	26.8	16.1	44.2	45.5	45.9
>80,000 NTD/month	0.00	0.00	6.20	22.8	24.7	20.9
Smoking (Yes, %)	19.3	27.9	28.9	2.83	2.16	6.96
Drinking alcohol (%)						
Yes, with the habit	29.5	27.3	41.0	5.99	5.17*	5.44
Yes, without the habit	33.8	30.7	17.9	36.5	34.3	20.6
Never	36.7	42.0	41.0	57.5	60.6	74.0
Betel nut chewing (Yes, %)	40.2	47.1	41.2	0.07*	0.34	0.31
Leisure-time energy expenditure (kcal/week)	752.5±62.8	1573±430	-	916.0±27.1	1106±90.6	-
Weight (kg)	64.0±1.45	64.9±2.13	66.0±2.41	57.4±0.61	56.3±0.53	56.8±0.85
BMI (kg/m^2)	27.5±0.75	28.1±1.07	28.1±0.87	23.3±0.26	23.0±0.22	23.4±0.33
Waist circumference (cm)	85.8±1.22	86.8±1.80	88.3±2.08	76.7±0.80	76.0±0.70	76.8±0.88
TSF (mm)	29.2±1.53	29.6±1.44	30.7±1.64	26.1±0.99	25.8±0.93	26.7±0.82
MAMC (cm)	20.8±1.04	21.1±1.16	20.3±0.80	19.6±0.31	19.4±0.33	19.4±0.44
Dietary Diversity Score	3.51±0.32	3.44±0.17	3.51±0.14	4.75±0.07***	4.71±0.05***	4.17±0.11

Percentage and means (mean ± SE) were shown in the table.
MVI-LTPA (Moderate to vigorous intensity leisure-time physical activity) was defined as an additional energy expenditure of 300-2000 kcal per week[41].
Body mass index (BMI) = body weight (kg)/height^2 (meter^2).
Smoking: including sometimes or everyday and exclude former smoker; Betel nut: have the habit and current chewing.
†The inactive Indigenes as reference group to compare with any LTPA or MVI-LTPA groups. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
‡The inactive general population as reference group to compare with any LTPA or MVI-LTPA groups. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
Data were weighted for unequal probability of sampling design by SUDAAN software.

chewing (with MVI-LTPA less frequent) and DDS (with higher scores where there was any MVI-LTPA or LTPA) there is significant difference. Virtually all socio-economic and personal behavioural variables were different between IndT and GenT.

Indigenes of both genders had higher BMIs and WC than the general population, except for Indigenous men who were active and not different from their general population counterparts. In no case did LTPA allow for a lower BMI or WC within the Indigenes. WC for men is higher than that for women in the GenT (p<0.001), but not for IndT (p=0.724); these gender relationships are not detectably altered by LTPA. Indigenous women, but not men, had higher TSFs than the GenT; and LTPA made no difference except for GenT men where TSF was lower with any-LTPA. For either population, neither men nor women had apparent differences in MAMC in relation to ethnicity or LTPA. Indigenous men had higher obesity prevalences (BMI ≥30 kg/m^2) than the GenT with any LTPA as well as in women. In the GenT, inactive men had higher obesity prevalences whether assessed by BMI ≥ 30 kg/m^2 or TSFs than with any LTPA or MVI-LTPA. Indigenous women had a higher abdominal obesity prevalence than the GenT in each LTPA group (MVI-LTPA, with any LTPA, and inactive). (Figure 2)

Table 2 indicates that, by age and gender, IndT engaged less frequently in more vigorous LTPA than the GenT, especially among older men, as reflected in the LTEE distributions. There were 33.3% (33.8% men; 32.8% women) in GenT and 53.8% IndT (54.6% men; 52.9% women) without LTPA. Only 21% IndT had LTEE ≥1000 kcal/week compared with 32.5% in the GenT. There were 41% elders aged ≥65y in the GenT who expended at least 1000 kcal/week in LTPA (50.6% men; 31.2% women); however, only 13.8% who were Indigenous achieved ≥1000 kcal/week (10.2% men; 16.8% women). The prevalence of 'no leisure-time activity' among Indigenous elders was greater than that in the GenT (48.2% vs 31.2%), especially for elderly men (56.2% vs 26.3%).

Table 3 shows the age-specific percentages of the population with any and for different activities. For any LTPA, IndT was less frequently engaged than was the GenT, overall (46.2 vs 66.7%, p<0.01) and for both men (45.4 vs 66.2%, p<0.01) and women (47.1 vs 67.3%, p<0.01). Elders in the GenT had the most engagement in traditional Chinese exercise (p<0.001), especially women (p<0.001) and the least with ball games (p<0.001). Adults aged 19-30 years had the most engagement with ball games (but not IndT) and the least with traditional Chinese exercise. Indigenous women, 31-44 years and ≥65 years engaged in relatively more gymnastics and dance than other age groups (p=0.009) yet women in the general population engaged more frequently in these than did Indigenous women. Compared to other age groups, elderly men in general had the highest percentage who walked, ran, and bicycled and the 19-30 year-old group had the lowest (p=0.013). For both genders, 'ambulation' are more common in the GenT than among IndT (p<0.01).

Figure 3 shows the proportions of IndT, GenT, and the American public that expends ≥1000 kcal per week. Exercise prevalence in Taiwan is much lower than that in the US during youth and early- to middle-age (18-64 years), but there is convergence with advancing years. The Indigenous exercise prevalence rate is similar to that for Taiwan at-large in the 18-44 y age group, but, after the age of 45, the GenT demonstrates increased exercise participation while that for IndT, this decreases. It is of some note that the commonality between the populations is for a decline in LTEE with age in both IndT and Americans, but not for the GenT.

Table 4 shows the risk for over-fatness or sarcopenia in two groups. These were adjusted for gender, age, educational level, household income, smoking, drinking, betel-nut chewing and DDS and were compared with those in the respective population for MVI-LTPA and LTPA with inactive as referent. In GenT, LTPA was associated with less risk of obese BMIs, obese TSFs, as indices of body fatness, and of sarcopenia in models 1, 2 and 3, The same applied to model 4 with adjustment for DDS, except for sarcopenia (MAMC ≤ 10th percentile), where the association was non-significant. In the IndT, there are no significant adjusted ORs for over-fatness in those who were active compared with those who were inactive except for sarcopenia where in models 1-4, the ORs for MVI-LTPA were 0.17 (95% CI, 0.03-0.82), 0.15 (95% CI, 0.02-1.01), 0.19 (95% CI, 0.05-0.70) and 0.13 (95% CI, 0.03-0.67) respectively; and for LTPA, they were 1.24 (95% CI, 0.38-4.02), 1.40 (95% CI, 0.36-5.41), 1.18 (95% CI, 0.39-3.56) and 2.02 (95% CI, 0.80-5.07), respectively. These findings indicate that LTPA engagement, as undertaken by Indigenes in mountainous Taiwan, does not adequately counter over-fatness or its distribution, but is associated with less risk of sarcopenia. Moreover, adjustment for DDS does not diminish this association between activity and reduced risk of sarcopenia. By comparison, in the general population, where leisure-time activity is associated with a greater DDS, sarcopenia, but not over-fatness, is dependent on DDS in the model.

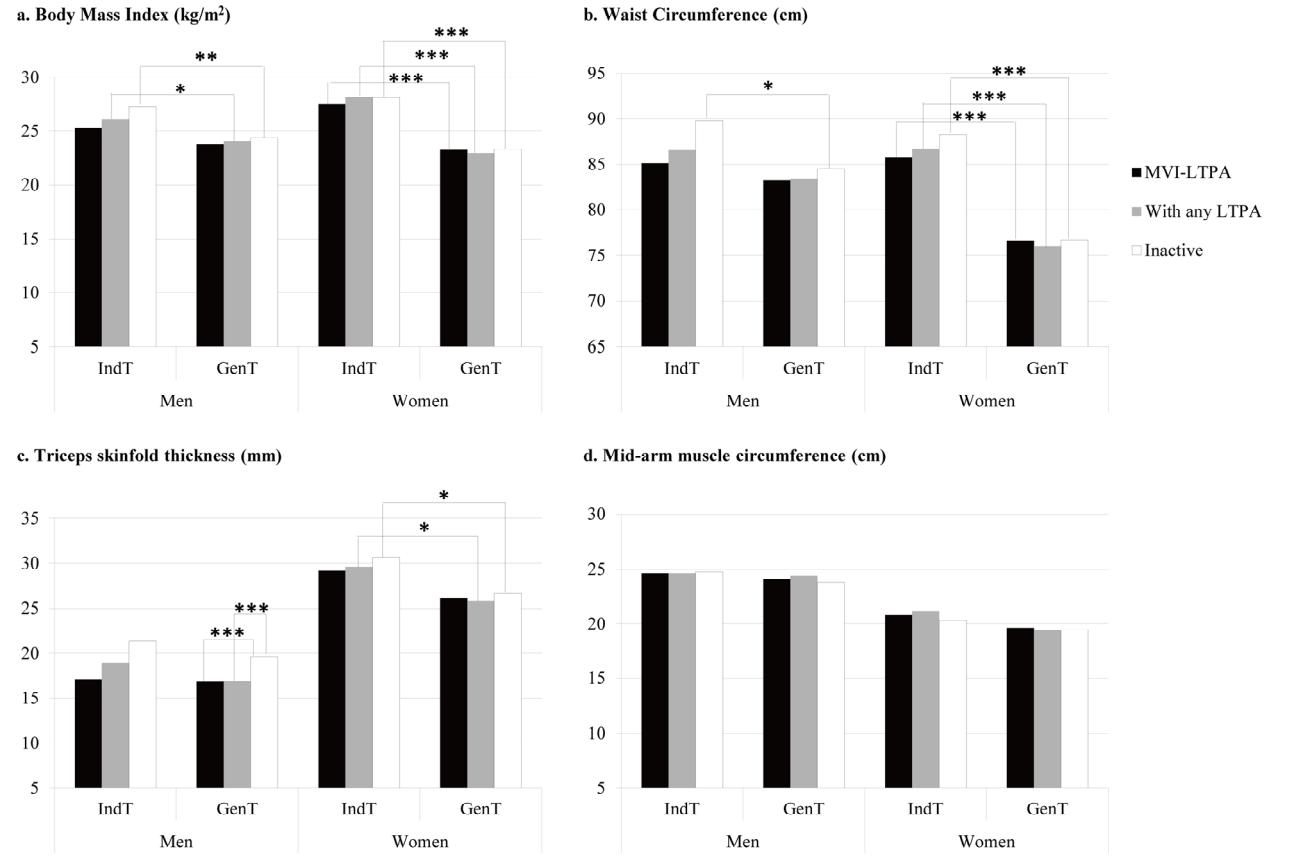
In the IndT, it was only possible, because of limited participation, to consider the risk of specific LTPA type on body composition for ambulation; no association was significant. Thus the most evident benefits of LTPA on body composition were in the GenT for ambulation with less sarcopenia. In order to consider whether engagement in 2 or more specific LTPA types might increase body composition benefit, we documented multiple engagement. The proportion of the GenT who undertook 2 or more types of LTPA was 16.5% and 3 or more was 1.34% (IndT only 7.54% and 0.56 %). This limited participation in multiple LTPAs precluded further evaluation. (Table 5)

DISCUSSION

There are striking differences between the Indigenous and general Taiwanese, on the one hand for indices of body fatness (BMI) and its distribution (WC although not TSF in men), but not in muscle mass (MAMC), and on the other in terms of levels of LTPA. Prima facie, therefore, there might be associations between body composition and LTPA which have an ethno-geographic explanation.

The links between LTPA and body composition

We have found that there is more over-fatness, but not less muscle as judged by MAMC, in Indigenous men and women than in the general population. LTPA of all types,



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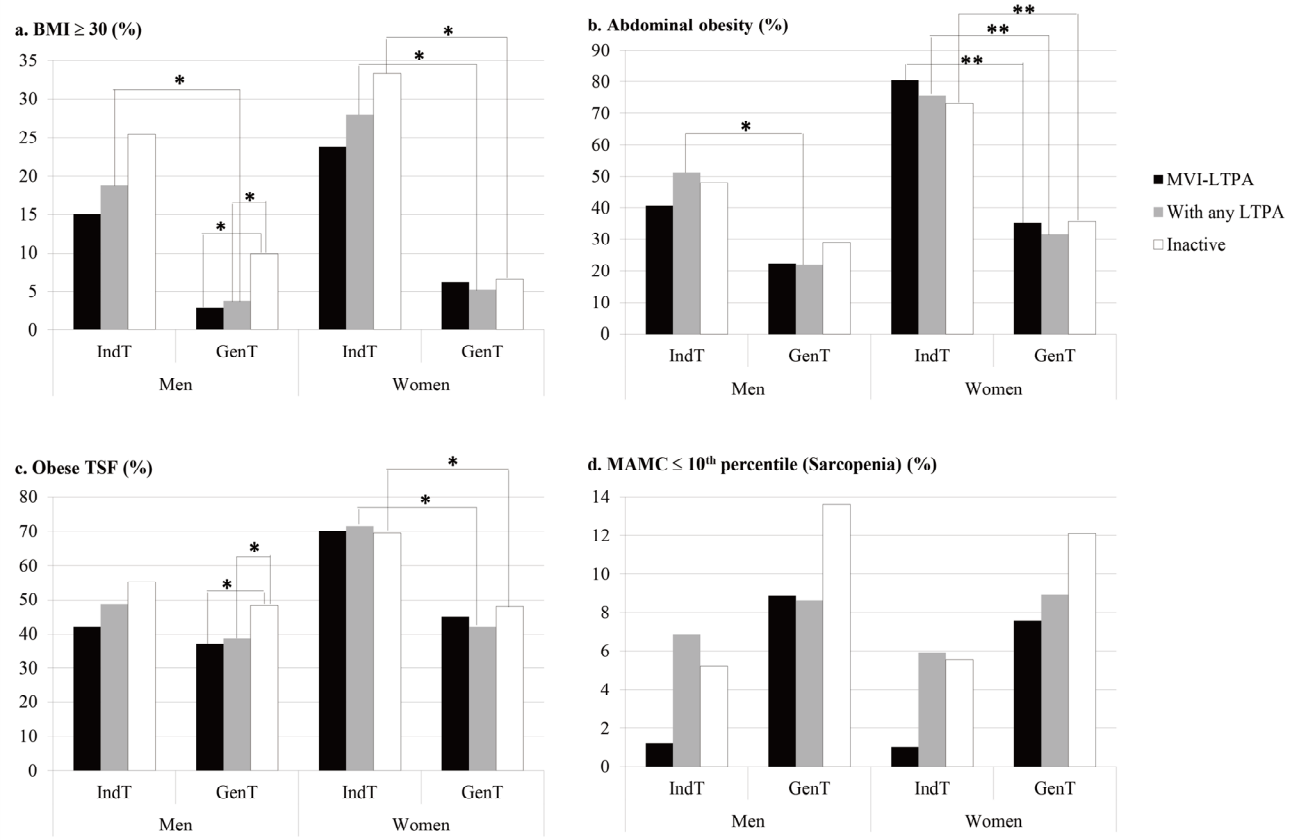

(2b)

Figure 2. Body compositions for Indigenous and general gender-specific Taiwanese: inactive or with leisure-time physical activity. LTPA indicates any leisure-time physical activity and MVI-LTPA moderate to vigorous leisure time activity. Significant difference between the mean values for Indigenous (IndT) men and women from the general Taiwanese (GenT) is shown for each level of LTPA as $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$. For the comparison of with and without LTPA, the only body compositional variable, for either the general or Indigenous population, which is significantly different is TSF for men in the general population, where it is less with LTPA ($p<0.001$).

Table 2. Indigenous and general Taiwanese leisure-time physical activity energy expenditure prevalences (%) by gender and age.

	Leisure-time physical activity energy expenditure (kcal/week)										*p* value
	0 (N=628)		<300 (N=184)		300-1000 (N=362)		1000-2000 (N=268)		>2000 (N=270)		
	IndT	GenT	IndT	GenT	IndT	GenT	IndT	GenT	IndT	GenT	
Men											
Overall	54.6	33.8	2.39	8.85	18.0	17.2	13.4	18.1	11.6	22.0	0.042
19-30y	59.5	35.2	0.00	11.3	5.17	20.5	19.8	15.6	15.5	17.4	0.115
31-44y	53.9	34.0	0.00	9.38	24.9	12.0	14.1	17.8	7.06	26.8	0.137
45-64y	49.0	35.2	4.77	8.29	26.0	19.4	8.13	19.5	12.1	17.6	0.513
≥65y	56.2	26.3	10.7	4.07	22.8	19.0	3.41	20.6	6.79	30.0	0.010
Women											
Overall	52.9	32.8	10.1	17.1	20.7	25.0	5.38	14.7	10.9	10.4	0.003
19-30y	63.9	38.3	8.41	14.9	13.9	26.6	4.20	16.5	9.66	3.72	0.175
31-44y	42.9	30.1	9.48	21.6	28.1	29.2	0.00	9.07	19.5	10.1	0.136
45-64y	56.6	29.8	8.61	16.3	19.4	21.2	9.58	17.4	5.85	15.3	0.179
≥65y	41.7	36.1	18.8	12.2	22.8	20.6	10.5	18.8	6.26	12.4	0.369

Chi-square test was used to determine the differences in the leisure-time physical activity energy expenditures between the Indigenous and general populations. Significance was regard as $p<0.05$.

especially traditional Chinese, gymnastics and dance, and ambulation were less common among Indigenes. Descriptively, engagement in LTPA is not associated with a healthier body composition except for less appendicular fat in men in the general population. But when adjusted for potential confounders, the models show that moderate intensity LTPA (range 300-2000 kcal/week) is associated with less sarcopenia in the GenT and in the IndT. MVI-LTPA is also associated with less total and appendicular obesity in the GenT and in the IndT. However, MVI-LTPA is not associated with recognizably less abdominal obesity (WC) in either population. Thus MVI-LTPA would seem to be associated with a healthier body composition except for central fat distribution. The health advantages of the MVI-LTPA-related findings are of relevance as to how 'sarcopenic obesity' might contribute to health in its own right, independent of truncal or visceral fat;[23] evidence points to reduced disability, frailty and improved survival as the favorable outcomes.[8,40] All of the possible benefits of LTPA on body tissues may not be reflected in body composition, however, and this applies particularly to muscle function and strength[23] as well as to the growing number of adverse effects of over-fatness including endocrine and inflammatory disorders.[48]

Our study can be related to that of Wen *et al*.[41] which determined the minimum amount of physical activity required to extend life expectancy in the Taiwanese population as 15 minutes per day. In that study the case for LTPA as a valuable predictor of health outcomes is made and LTPA is classified as moderate or vigorous intensity. Our MVI-LTPA corresponds to the range of 300-2000 kcals per week or about 40-300 kcal per day. Several studies show that, for significant improvements in life expectancy, about 300-500 kcal per day extra in nutritious food intake, matched by that level of energy expenditure are worth while,[38] which is around an hour's walk. There are likely benefits of LTPA over and above the achievement of energy balance and a desirable body composition, which may enhance survival at the minimum amounts.[41] In our study. while we can speak of the range of LTEE from 300-2000 kcal/week as one over which we see associations between LTPA and body composition, the design does not allow dose response conclusions to be reached. But we can concur with other studies in the same population in regard to the utility of this range in body composition-related health advancement.[41,49]

An example of benefits which might accrue uniquely to the GenT of LTPA adherents in Taiwan, might be those through participation in traditional Chinese LTPA, especially Tai-Chi. It was the only form of LTPA not practiced by IndT and the form which characterises LTPA in the population ≥45 years. We have, therefore, considered its association with body fat, its distribution and of sarcopenia in the GenT, but found none significant (data not shown). However, also in Taiwan, Yu *et al*, in an intervention study with Tai-chi, found less subcutaneous adipose tissue at the abdomen and thigh compared with controls.[50]

It is noteworthy that the GenT has lower non-significant ORs for MVI-LTPA on the body composition variables of BMI ≥30 and obese TSF, but significant for sarcopenia, compared with the IndT. In the GenT as well, MVI-LTPA has a protective association insofar as sarcopenia is concerned. In addition, we found less risk of sarcopenia in the GenT. Traditional Chinese physical activity (eg Tai-Chi) was the unique differentiator between ethnic groups for MVI-LTPA. However, other forms of LTPA, ambulation, gymnastics and dance, but not ball games, were more prevalent among the general than the Indigenous population. There would appear to be ethnic, demographic and geographic disparity in body composition risk reduction through LTPA when overall LTPA patterns are considered.

Particular LTPAs and BCDs

Of the particular LTPAs most widely practiced by the IndT and GenT, aerobic gymnastics and dance and 'ambulation' are the most popular. In fully adjusted models, including diet, only ambulation has a significant beneficial association for a body composition variable, which is sarcopenia. However, any one for of LTPA occurs in a collective LTPA culture so that its success might depend on participation in a variety of activities provided that, to

Table 3. Different leisure-time physical activity (LTPA) engagements: Indigenous and general Taiwanese by gender and age (%)

Age	Any LTPA		Traditional Chinese exercise		Ball games		Gymnastics and dance (Aerobic)		Ambulation (Walking, running, or bicycling)	
	IndT	GenT	IndT	GenT	IndT	GenT	IndT	GenT	IndT	GenT
Overall	46.2	66.7**	0.94	4.66**	8.84	8.81	7.78	16.1**	36.7	55.0**
19-30y	38.7	63.2*	0.00	0.65	13.7	17.8	0.00	19.2**	28.1	44.8
31-44y	51.6	67.9*	3.54	4.55	10.3	10.1	15.4	14.8	43.4	55.3
45-64y	47.5	67.5	0.00	6.65***	4.38	3.23	6.77	14.8	40.3	61.3
≥65y	51.8	68.8	0.00	7.98***	2.70	1.73	15.7	16.6	36.7	58.7
p value†	0.577	0.639	-	<0.001	0.122	0.001	0.013	0.584	0.481	0.130
Men	45.4	66.2**	1.74	3.80	9.86	13.7	4.69	12.1*	36.4	53.4*
19-30y	40.5	64.8*	0.00	1.36	16.6	25.5	0.00	17.5*	29.1	36.0
31-44y	46.1	66.0	7.06	2.47	7.06	16.5	7.06	13.2	39.1	54.0
45-64y	51.0	64.8	0.00	6.23**	6.06	5.97	7.70	5.98	42.8	60.4
≥65y	43.8	73.7	0.00	5.63**	3.41	3.44	6.79	15.3	35.7	67.2
p value†	0.854	0.103	-	0.216	0.291	0.001	0.099	0.029	0.580	0.013
Women	47.1	67.2**	0.00	5.51***	7.66	4.00	11.4	20.0**	37.1	56.7***
19-30y	36.1	61.7*	0.00	0.00	9.66	10.8	0.00	20.7**	26.5	52.7*
31-44y	57.1	69.9	0.00	6.69	13.6	3.38	23.8	16.5	47.8	56.7
45-64y	43.4	70.2	0.00	7.07**	2.34	0.49	5.65	23.7*	37.1	62.1*
≥65y	58.3	63.9	0.00	10.4**	2.12	0.00	22.9	17.9	37.5	50.2
p value †	0.403	0.259	-	<0.001	0.140	0.029	0.009	0.510	0.438	0.085

The significance of differences between Indigenous and General Taiwanese with or without physical activity in Chi-square test is shown by: *$p<0.05$, **$p<0.01$, ***$p<0.001$

†In the case of differences in physical activity by age, the *p*-value of Chi-square test is shown at the bottom of the relevant column.

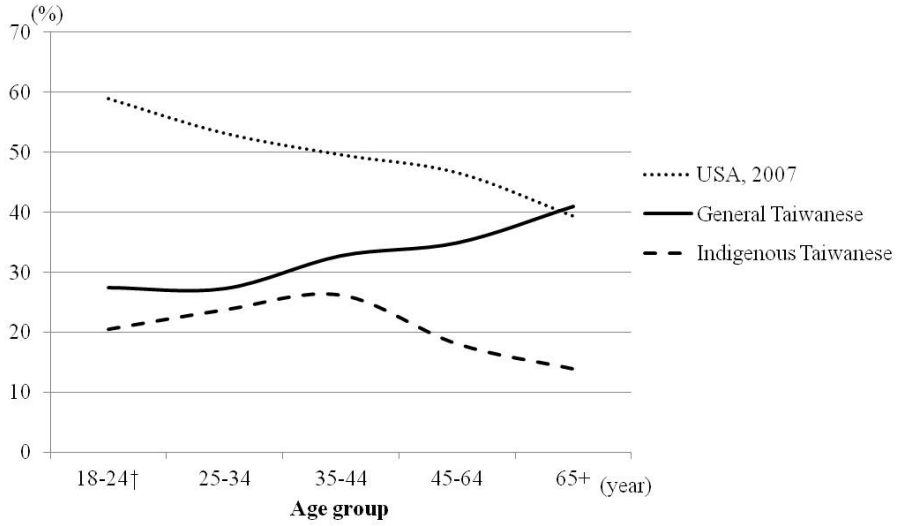

Figure 3. Population prevalences for moderate leisure-time physical activity energy expenditures. Leisure-time physical activity energy expenditures ≥ 1000 kcal/week (walking at least 30 minutes per day) for Indigenous Taiwanese, the General Taiwanese population, and Americans[87] †19-24 years for Indigenous Taiwanese and the General Taiwanese population

Table 4. Obesity risk among Indigenes and the general Taiwanese population with MVI-LTPA[a] or LTPA (OR, 95% CI)

	Indigenous Taiwanese			General Taiwanese		
Obesity	Inactive	With MVI-LTPA[†]	With LTPA	Inactive	With MVI-LTPA[†]	With LTPA
BMI ≥ 30						
Model 1	Ref	0.55 (0.21-1.46)	0.70 (0.32-1.53)	Ref	0.53 (0.29-0.97)	0.52 (0.31-0.88)
Model 2	Ref	0.31 (0.09-1.06)	0.74 (0.30-1.83)	Ref	0.60 (0.27-1.33)	0.67 (0.35-1.29)
Model 3	Ref	0.40 (0.15-1.06)	0.53 (0.23-1.23)	Ref	0.67 (0.34-1.32)	0.53 (0.31-0.91)
Model 4	Ref	0.61 (0.25-1.51)	0.73 (0.30-1.79)	Ref	0.51 (0.28-0.93)	0.53 (0.31-0.91)
Abdominal obesity[‡]						
Model 1	Ref	1.01 (0.37-2.75)	1.21 (0.48-3.03)	Ref	0.80 (0.55-1.16)	0.70 (0.50-0.99)
Model 2	Ref	1.13 (0.43-2.94)	1.57 (0.68-3.64)	Ref	0.80 (0.52-1.22)	0.75 (0.53-1.06)
Model 3	Ref	0.83 (0.38-1.80)	1.17 (0.49-2.83)	Ref	0.88 (0.61-1.27)	0.73 (0.50-1.07)
Model 4	Ref	1.22 (0.40-3.75)	1.29 (0.49-3.44)	Ref	0.82 (0.57-1.18)	0.70 (0.49-1.01)
Obese TSF[§]						
Model 1	Ref	0.83 (0.24-2.88)	1.01 (0.34-2.96)	Ref	0.75 (0.60-0.93)	0.71 (0.58-0.88)
Model 2	Ref	0.81 (0.16-4.07)	1.15 (0.34-3.86)	Ref	0.73 (0.53-1.00)	0.75 (0.58-0.98)
Model 3	Ref	0.56 (0.18-1.78)	0.74 (0.33-1.70)	Ref	0.76 (0.58-0.99)	0.69 (0.53-0.91)
Model 4	Ref	0.97 (0.29-3.23)	1.08 (0.38-3.06)	Ref	0.77 (0.59-1.00)	0.77 (0.60-0.98)
Sarcopenia[¶]						
Model 1	Ref	0.17 (0.03-0.82)	1.24 (0.38-4.02)	Ref	0.61 (0.38-0.98)	0.65 (0.45-0.95)
Model 2	Ref	0.15 (0.02-1.01)	1.40 (0.36-5.41)	Ref	0.46 (0.26-0.80)	0.45 (0.30-0.67)
Model 3	Ref	0.19 (0.05-0.70)	1.18 (0.39-3.56)	Ref	0.53 (0.30-0.93)	0.60 (0.37-0.97)
Model 4	Ref	0.13 (0.03-0.67)	2.02 (0.80-5.07)	Ref	0.61 (0.37-1.01)	0.70 (0.46-1.07)

OR (95% CI) is Odds Ratio with 95% confidence intervals; LTPA is Leisure-time physical activity; MVI-LTPA is Moderate to vigorous intensity leisure-time physical activity.
[†]MVI-LTPA was defined as an additional energy expenditure of 300-2000 kcal per week.[41]
[‡]Abdominal obesity was defined by a waist circumference (WC), ≥90 cm for men and ≥80 cm for women.
[§]Triceps skinfold thickness (TSF) was categorized as obese if, >18 mm for men or >26 mm for women.
[¶]Mid-arm muscle circumference (MAMC) ≤ 10th percentile was regarded as sarcopenic: the 10th percentile was applied by gender and age group (19-30y, 31-44y, 45-64y, ≥65y) in the general or Indigenous Taiwanese population.
Model 1: adjusted for age and gender
Model 2: Model 1 + education level and household income
Model 3: Model 1 + smoking, drinking, and chewing betel nuts
Model 4: Model 1 + dietary score (Dietary Diversity Score, DDS)

do so was sufficiently motivating and sustainable. Organisations like the American College of Sports Medicine recommend regular adherence to a community or socially-based activity on the one hand and the need to avoid boredom on the other hand for long-term benefit.[51]

Ball games, as discussed elsewhere this paper, have the characteristics of involving groups of people to interest and pace each other, but, at the same time may not cater well for the diverging physiological capabilities of individuals with age. They did not prove to have significant BC associations in adjusted models which included diet.

It is arguable the extent to which Traditional Chinese LTPA might be transferable to the Indigenous community and what the benefits might be. We could only assess its

Table 5. Body compositional abnormality risk among Indigenes and the general Taiwanese by LTPA type when inactive

	Indigenous Taiwanese	General Taiwanese			
	Ambulation	Traditional Chinese exercise	Ball games	Gymnastics and dance	Ambulation
Number (Yes/No)	86 / 140	83 / 1403	86 / 1400	216 / 1270	831 / 655
BMI ≥ 30					
≥19y	1.57 (0.52-4.70)	-	3.24 (0.36-28.8)	0.93 (0.27-3.17)	1.60 (0.66-3.89)
≥45y	1.70 (0.45-6.45)	-	-	0.76 (0.22-2.69)	2.05 (0.63-6.65)
Abdominal obesity[†]					
≥19y	0.73 (0.26-2.02)	0.85 (0.37-1.95)	2.44 (0.81-7.36)	1.47 (0.84-2.58)	1.08 (0.72-1.64)
≥45y	0.92 (0.20-4.21)	0.87 (0.44-1.73)	0.53 (0.18-1.60)	1.05 (0.56-1.95)	1.00 (0.65-1.53)
Obese TSF[‡]					
≥19y	1.24 (0.40-3.87)	0.93 (0.51-1.72)	1.51 (0.62-3.66)	1.54 (0.97-2.46)	1.02 (0.73-1.43)
≥45y	3.43 (0.91-13.0)	1.21 (0.57-2.57)	1.56 (0.39-6.27)	1.18 (0.73-1.92)	0.77 (0.50-1.18)
Sarcopenia [c]					
≥19y	0.77 (0.26-2.25)	2.13 (0.55-8.27)	0.76 (0.27-2.11)	1.54 (0.89-2.67)	2.07 (1.26-3.43)
≥45y	7.00 (0.77-63.4)	1.08 (0.24-4.78)	0.87 (0.12-6.41)	3.09 (0.92-10.3)	1.34 (0.79-2.27)

Adjusted OR (95% CI) are shown in this table, and models adjusted for gender, age, education level, household income, smoking, drinking, chewing betel nuts, and dietary diversity score (DDS). Subjects who undertake LTPA serve as the reference group.
[†]Abdominal obesity was defined by a waist circumference (WC), ≥90 cm for men and ≥80 cm for women.
[‡]Triceps skinfold thickness (TSF) was categorized as obese if, >18 mm for men or >26 mm for women.
[§]Mid-arm muscle circumference (MAMC) ≤ 10th percentile was regarded as sarcopenic: the 10th percentile was applied by gender and age group (19-30y, 31-44y, 45-64y, ≥65y) in the general or Indigenous Taiwanese population.

association with body composition in the GenT, since it was scarcely used in the IndT, and could not identify any body composition association. However, there is other evidence for its benefits and persistence among especially older members of the community.[9] It may also have a facilitatory role, by improving an individual's capability for other activities, or by virtue of its strong socio-cultural significance and associated adherence.

Ageing, LTPAs and BCDs

Of particular interest is the recognition that the proportion of the GenT which engages in MVI-LTPA is greater with advancing years. However, this is not seen with the IndT, which resembles the US population in this regard in its decrease in late life. Both the US and IndT experience a high prevalence of obesity, but their early life LTPAs are strikingly different, with twice the prevalence among US youth. Since our studies are cross-sectional, we cannot be sure about life-long conjoint trajectories in LTPA and BCD, but it is possible that LTPA might be more preventive against BCD if in place throughout life.

Explanatory considerations for the linkages

Both populations studied benefitted from MVI-LTPA insofar as sarcopenia is concerned, although the GenT, principally ethnic Chinese, were more prevalent users of all forms of LTPA and the body composition benefits extended to body fatness for them.

Cross-cultural uptake of unfamiliar LTPAs is bound to be limited unless there are incentives. In the present study, traditional Chinese LTPAs have not been incorporated into the LTPA patterns of IndT. This may be for a variety of historical and contemporary reasons to do with survival of a minority in the face of a majority culture.[52] The other way round, majority cultures increasingly assimilate practices or customs like Tai-Chi from minority ethnic Chinese members of the community.[53]

Problems of accessibility to LTPA may apply broadly, but for different reasons. The less dependent on facilities, like recreational space, the less likely the impediments to participation should be.

With regard to the differences in LTPA by age and gender; in women, traditional Chinese exercise increase with age, in men, it decreases for ball games and increases for 'ambulation' with age. Fries reported that, if regular physical activity is in place before 55 years of age, the reduction in later life disability, some of which will relate to BCD, can be substantial.[54] Knowledge or health literacy of this kind can be motivating for LTPAs.

We are unable to identify particular strategies for maintenance of LTPAs in our study. However, the differentials between mountainous IndT and the GenT in uptake suggests that existing communities could be strengthened in their capacity to link the health agenda more effectively to body composition risk management by way of LTPAs.

If LTPA can itself support socialisation, it has an added raison d'être which could encourage sustainable LTPA initiatives.

Implications for Indigenous Taiwanese

The LTPAs in which IndT engage are, in order of frequency, ambulation, ball games, gymnastics and dance and, very rarely, traditional Chinese exercise. Neither MVI-LTPA nor LTPA, as enjoyed by IndT, could be shown to be protective against obese BMI, abdominal obesity, or obese TSF,;but MVI-LTPA was associated with less sarcopenia. Since in the GenT, such activities were associated with less obese BMIs and obese TSFs, an activity pattern which included traditional Chinese exercise might be worthwhile. Tai-Chi also has recognised benefits in the reduction of cardiovascular risk[55] and the amelioration of respiratory insufficiency in chronic obstructive lung disease.[56]

Reducing the burden of BCD

Our work has identified the potential usefulness or otherwise of some forms of LTPA enjoyed in Taiwan to reduce the burden of body compositional disorders and related disease such as CVD, cancer, and neurodegeneration.[7,8,57-63] These may reflect energy imbalance or dysregulation which characterises over-fatness, sarcopenia, impaired glycaemic regulation and insulin resistance.[2,8]

The findings cannot be seen in isolation from the socio-economic and personal behavioural problems which beset the IndT, notwithstanding our adjustments for these.[64,65] The composite of unhealthy behaviours which contributes to health and life expectancy differentials is rooted in inequity.[66] The LTPAs which we have found to be associated with healthier body composition are also ones with psychosocial, as well as biomedical advantage.[41,67] The difference between the rates of smoking and betel quid chewing contributes to approximately one quarter of the 13 years difference in life expectancy.[68] Thus the further pursuit of our findings through policy research may help close the Indigenous to non-Indigenous health gap in Taiwan.[49,59,61,63,69-77]

The extent of the LTPA problem

Our study confirms that the prevalence and amount of physical activity in Taiwan are roughly half of those in the US.[10] After middle age, the ratio of the IndT to GenT LTPA participation rate is 0.5 (45-64y) and only 0.3 in the elders. About 41% of elders had LTEE ≥1000 kcal/week, but only 14 % were Indigenous. Indigenes have a higher prevalence of obesity when compared with the Taiwanese at large. Engagement in LTPA among IndT ≥45 years is less than one third of the Taiwanese average[10] and our findings indicate a 2-fold difference in engagement in LTPA. Obesity-linked poor health of Indigenes is likely to be partially related to physical inactivity and the present findings support this. Indigenes lack both quantity and quality of physical activity, especially from middle age onwards. WHO considers that the relative attributions to personal health are of the order of 20% to genetics, 19% to environmental factors, 10% to medical conditions, and 51% to individual behaviour.[49,59,61-63,68-78] With socio-economic disadvantage and inequity these estimates may well be skewed further away from the Mendelian genetic attribution. Thus, for the disadvantaged IndT, opportunities for health advancement through LTPA may be appreciable.

LTPA facilities and resources

With the introduction of a national health insurance program in 1995, many barriers to medical accessibility were removed. Local hospitals and clinics provided more targeted Indigenous health services,[76] with integrated delivery system to remote mountainous areas.[17] Yet gaps remain especially in preventive programs of which LTPA and nutrition must be part, along with concomitant risk factors like smoking, chewing betel quid, and drinking alcohol.[65] The particular advantage of physical activity as a lead initiative is that it promotes mental and physical health as stepping stones to other behavioural change. Physical activity, independent of body fatness, decreases the burden of chronic disease like diabetes[79] and of premature mortality.[80] In our study, we have adjusted for factors which might have confounded our findings. With these adjustments, themselves each of health relevance, the association of leisure-time activity on body composition is most cross-culturally robust for less sarcopenia, itself of considerable health relevance throughout the life-course.[46] Thus, recreational physical activity should be a feasible way to improve Indigenous Taiwanese health.

Locality or community-based approaches

Indigenous peoples are at particular risk of losing their traditions to those which characterize those of the majority population's disadvantaged members for a variety of reasons, notably through social, cultural and geographical isolation.[81] Food culture has endurance, but even this is sorely tested by the present rate of food system change. So it is not surprising that Indigenous people are vulnerable to cheap, ready-to-eat foods with ingredients of poor nutritional quality like refined carbohydrates, fat and salt. Food diversity is a measure of food security[44] and, in Taiwan, costs more than does diverse diet.[82] Similar challenges exist for physical inactivity, the other side of the energy balance equation and which may lead to obesity, sarcopenia and osteopenia.[83,84] The present study suggests that recreational facilities to enhance participation in traditional LTPAs of both the Indigenous minority and the general population might reduce the risk of body compositional disorders at-large. These may simply require accessible and safe open space with minimal investment in the environment, given the types of physical activity identified as of potential value. They may be available in urban or rural settings, including those in Indigenous areas. At the same time, programs in health literacy which link knowledge of LTPA to understandable and meaningful measures of body composition, and not just weight, will encourage more sustainable lifelong approaches to healthy weights. Implicit in our findings that socio-economic and personal behavioural factors cluster with body compositional disorders is that there are underlying and amenable social and environmental factors which enable LTPA to prosper and to affect body compositional health. Primary prevention can be emphasized while corrective programs are accommodated for body compositional disorders at the individual or community level. An increase in body weight of friends and family increases the possibility of personal obesity by 10%.[85] The corollary that these considerations might apply to prevention is evident. Moreover, these opportunities are more likely to be operational where there is community commitment[19] and there is an emphasis on healthy environments.[20]

Limitations

There are some limitations with our study. One derives from the strength that it has provided an opportunity to study mountain-dwellers and IndT, but these characteristics are not sufficiently separable. We have adjusted for them and the findings are correspondingly robust. But it does mean that we cannot be sure of the extent to which ethnicity or locality accounts for the practice or type of LTPA, nor of how it associates with body composition. It is also the case that the GenT used as reference, while dominantly Han and urban, has a variable Indigenous

ancestral admixture.[86] Moreover, the assignment of indigenous ethnicity in this study was paternal, when a major proportion of IndTe abide by maternal ancestral traditions. Nevertheless, traditional Chinese exercises, like Tai-Chi and folk dance are readily identifiable and constitute a major part of the study LTPA among the GenT who participate. We do find, though, that LTPA with no particular ethnicity; to do with ambulation were much more undertaken by the GenT than the IndT. Hypothetically, we subscribed to the assumption that mountain-dwelling Indigenes would have engaged more frequently than the referent general population in ambulatory activities, but this did not appear to be so. We can, therefore, deduce that both ethnic and ecological factors have operated to produce the associations evident between LTPA and body composition.

Conclusions

The differences in LTPA and body composition between Indigenes and general Taiwanese demonstrate that vulnerability to sarcopenia in the general population is reduced by an LTPA pattern in which traditional Chinese exercise like Tai-Chi together with ambulation by way of walking, running and bicycling are practiced. With these activities, the general population also minimised the risk of total body and appendicular fatness and limited sarcopenia. At the same time, mountain-dwelling Indigenes are prone to total body and abdominal over-fatness which is not sufficiently countered by the forms of LTPA undertaken irrespective of age and gender. Given the recognised health importance of body compositional change, this comparative study of relationships with traditional and available forms of leisure-time physical activity offers useful policy direction.

ACKNOWLEDGEMENTS

The authors declare that they have no conflicts of interest with regard to the content of this article. The study reported is part of a National Health Research Institutes project (PH-101-PP-26), and the data were provided by the Nutrition and Health Survey in Taiwan (NAHSIT), Food and Drug Administration, and Department of Health in Taiwan, administrated by Dr Wen-Harn Pan, Institute of Biomedical Sciences, Academia Sinica, Taiwan. The authors would like to thank Dr Pan for providing the data and critical support for this project. We would also like to thank Dr Hsing-Yi Chang, Institute of Population Health Sciences, NHRI, Taiwan for her statistical advices. The interpretations and conclusions reached herein do not represent those of the Food and Drug Administration, the Department of Health, or the National Health Research Institutes.

AUTHOR DISCLOSURES

No author has a conflict of interest

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Original Article

Leisure time physical activities and dietary quality of the general and indigenous Taiwanese populations are associated with fat distribution and sarcopenia

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臺灣地區群體與原住民成年人休閒體能活動量及飲食品質與體脂分佈及肌少症之關係

臺灣原住民因為各種原因而有較高與肥胖相關之健康風險。本研究在探討及比較 2005-2008 年國民營養健康狀況變遷調查的 19 歲以上臺灣整體樣本(n=1486)與原住民(n=226)的運動、身體質量指數(BMI)、脂肪分佈(腰圍及三頭肌皮脂厚度(TSF))和中臂肌肉圍(MAMC)。以運動代謝當量(METs)計算研究對象休閒體能活動量(LTPA)，並進行兩組樣本的比較。結果發現，原住民男性及女性的肥胖(BMI≥30 kg/m^2)盛行率分別是臺灣整體樣本中成年男性及女性的 3.81 和 5.47 倍；約有 55%的原住民以及 34%的臺灣人沒有休閒運動，而原住民的休閒運動種類也明顯的較少；經過年齡、性別、教育程度、收入、抽菸、飲酒、嚼食檳榔、及飲食品質校正後，適度運動之原住民與台灣整體族群中，有肌少症的風險，分別是沒有運動者的 0.13 倍(OR=0.13, 95% CI: 0.03-0.67)及 0.61 倍(OR=0.61, 95% CI: 0.37-1.01)；而有運動的台灣成年人中，BMI≥30 kg/m^2 和以 TSF 定義之肥胖風險，分別是沒有運動者的 0.53 倍(OR=0.53, 95% CI: 0.31-0.91)及 0.77 倍(OR=0.77, 95% CI: 0.60-0.98)。在未校正飲食品質之前，有運動對臺灣成人肌少症的風險具有顯著的保護作用(OR=0.60, 95% CI: 0.37-0.97)，校正飲食品質後其顯著性則消失。進一步分析運動類型對肥胖之影響，進行步行運動的臺灣成年人被發現有較低的肌少症風險(OR=2.07, 95% CI: 1.26-3.43)。休閒體能活動降低肌少症的風險與種族無關，而在台灣成人中，一定程度上與飲食有關，並且會降低肥胖風險。

關鍵字：肥胖、運動、能量消耗、體組成、肌肉