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Original Article

Patterns of Lifestyle Behaviors and Relevant Metabolic Profiles in Chinese Adults: Latent Class Analysis from Two Independent Surveys in Urban and Rural Populations

Qian Cui [1], Ying Chen [2], Xinhua Ye [1], Yamei Cai [3], Rui Qin [3], Tao Chen [4], *Ting Yan [5], Dahai Yu [6]

1. *Department of Endocrinology and Metabolism, the Affiliated Changzhou No.2 People's Hospital of Nanjing Medical University, Changzhou, Jiangsu, China*
2. *Department of Health and Environmental Sciences, Xi'an Jiaotong-Liverpool University, Suzhou Jiangsu 215123, China*
3. *Jiangsu Province Hospital on Integration of Chinese and Western Medicine, Nanjing 210028, China*
4. *Liverpool School of Tropical Medicine, Pembroke Place, Liverpool L3 5QA, United Kingdom*
5. *Department of Nursing, the Affiliated Changzhou No.2 People's Hospital of Nanjing Medical University, Changzhou, Jiangsu, China*
6. *School of Medicine, Keele University, Staffordshire, United Kingdom*

***Corresponding Author:** Email: tingyan253@gmail.com

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Abstract

Background: This study was determined to describe the patterns of lifestyle behaviors and their associations with metabolic profiles among Chinese urban and rural adults.

Methods: This was a cross-sectional study set in the Nanjing (5,824) and Hefei (20,269) Community Cardiovascular Risk Surveys from 2011-2013, using random cluster sampling. Questionnaires were completed via face-to-face interview, and data on lifestyle behaviors including daily night sleep duration, nap duration (if any) and sitting time, and weekly physical activity (measured using the International Physical Activity Questionnaire, in metabolic equivalents of task × minutes, and separated into walking and moderate-to-vigorous physical activity (MOVPA) according to intensity) was collected. The patterns of physical activity in Chinese urban and rural populations and the metabolic profile in each pattern were identified by the latent class analysis.

Results: Six distinct clusters were determined, with the sizes ranging from 45% to 5% of the total population. For example, the most common cluster was associated with a sufficient night and nap sleep duration, a long sitting time, and above WHO recommended physical activities for both walking and MOVPA, and the smallest cluster was featured by its huge amount of MOVPA and limited amount of walking activity. Difference in proportion of each cluster was observed between the two survey sites. No obvious abnormal blood measures were seen in any cluster.

Conclusion: Common lifestyle behavior clusters were described, leading to a better understanding of people's routine activities.

Keywords: Physical activity; Sedentary time; Sleep duration; Latent class analysis

Introduction

Physical activity, amount of sleep, sedentary time are independently associated with certain metabolic profiles, health indicators and all-cause mortality (1-3). These behaviors are influenced by local cultural and social settings such as rural versus urban (4; 5). To echo the increasingly important health issue that rural health is an important and dynamic concern around the world (4; 5), it would help health professionals to address this issue and provide tailored health care strategies by understanding the variance of physical activity patterns between urban and rural population, especially in developing countries. The way an individual engages in one behavior can influence engagement in other behaviors. Individual measure was often used to quantify certain behavior in an individual or population. However, the understanding of how multiple lifestyle behaviors, such as physical activity, sitting and sleep, co-occur within individuals is still in its very early phase (6).

Latent class analysis (LCA) is a structural equation modelling, applied to identity groups or subsets of cases in multivariate categorical data. Limited research describes the co-occurrence of lifestyle behaviors or further investigates their relationship with health outcomes in people living in China using this statistical tool, although a couple of investigations have been done outside of China (7-10).

We aimed to examine the patterns of lifestyle behaviors (including walking, moderate-to-vigorous physical activity (MOVPA), night sleep duration, nap duration, and sitting time) in Chinese using LCA. The secondary objectives were to explore the metabolic profiles (e.g. glucose, lipid profiles, creatinine) stratified by the identified LCA clusters.

Materials and Methods

We applied used two cross-sectional surveys in urban and rural Chinese populations from 2011-2013. The sampling method has been described previously (11).

The surveys were approved by the Institutional Review Board of Jiangsu Province Hospital on Integration of Chinese and Western Medicine (11-006). Signed consent was received from each individual who participated the research.

Paper questionnaires were completed via face-to-face interviews by trained research staffs in both surveys. Self-reported records on physical activity during a whole week prior to survey were collected through the long form of International Physical Activity Questionnaire (IPAQ) (12). Data were reported in metabolic equivalents of task (MET) × minutes per week (13). Activities with a period less than ten min were not included according to the IPAQ guideline. Activities in specific settings were categorized into two groups (i.e. walking (the most commonly performed light activity), MOVPA) according to IPAQ items and activity intensity (14).

Body measurements were taken three times using a standardized methodology, and the mean of the two closest recording was used (11; 15). Body mass index (BMI) was calculated based on the obtained body height and weight using kg/m^2.

Overnight fasting blood samples were collected by trained nurse (11). Plasma samples for measuring glucose and the serum samples for measuring lipid profile and creatinine were collected by standard method (11). Plasma glucose, serum creatinine, and serum lipid levels were measured by automated analyzer (Olympus AU600 autoanalyzer (Olympus Optical, Tokyo, Japan)) (16).

Descriptive statistics was initially presented for participants' demographics, lifestyle variables and blood measures in individual and pooled populations.

LCA was applied to determine common patterns of physical lifestyle using the five lifestyle measures. For each one, data was normalized into a 1 to 10 scale before participating LCA in order to be equally-weighted-modelling. Min-max normalization was used as many lifestyle measures were not normally distributed. Potential influence from upper outliers was controlled by replacing values larger than the value of upper quartile plus 1.5 times of the interquartile range with this upper inner fence (i.e. the definition of mild outlier). The formula $X' = [(X - Min_{value})/(Max_{value} - Min_{value})]*(10 - 1) + 1$ was used for obtaining each normalized value allocated between 1 and 10 before it was further rounded to nearest ones whole number. The LCA clustered all into distinct groups based on patterns of lifestyle across the five variables, with each participant allocated into one cluster. We used Bayes Information Criterion (BIC) and Consistent Akaike's Information Criterion (CAIC) to determine the optimal model. Both the estimation-maximization and Newton-Raphson algorithms were used to estimate model parameters (17). One thousand different random starting values were used in the estimation, each of which included 100 iterations. Based on BIC and CAIC, the optimal model is the one with the lowest BIC&CAIC. Patients were allocated to clusters based on their posterior probabilities of belonging to each cluster. A mean posterior probability ≤ 0.3 for participants allocated to a cluster is considered low (unacceptable), and ≥ 0.7 was high (18). However, this judgment was also dependent on the total number of clusters where LCA models containing more clusters tend to have lower mean posterior probability for each cluster as the sum of total mean posterior probabilities (assigned and unassigned) equals 1. Based on the optimal model, the identified clusters were compared on participants' demographics and blood measure profiles.

Latent GOLD (version 4.5) was used to perform LCA. All other analyses were implemented using STATA-15.

Results

Overall 26093 participants (Nanjing 5824 and Hefei 20269) were included, with 42% of males. Characteristics of participants in each individual survey are also presented in Table 1.

Table 1: Participant characteristics on demographics, physical lifestyle, and blood measure profiles

Characteristics	*Nanjing (urban, n = 5824)* Mean (SD) or n (%)	*Hefei (rural, n = 20269)* Mean (SD) or n (%)	*Pooled (n = 26093)* Mean (SD) or n (%)
Demographical and physical			
Age, year	51.7 (9.9)	51.1 (9.9)	51.2 (9.9)
Male, %	2546 (43.7)	8364 (41.3)	10910 (41.8)
BMI, kg/m²	24.4 (4.1)	24.8 (4.0)	24.7 (4.0)
Heart rate, per minute	74.3 (10.5)	74.3 (10.7)	74.3 (10.7)
Systolic blood pressure, mmHg	130.8 (20.7)	135.0 (22.1)	134.1 (21.9)
Diastolic blood pressure, mmHg	81.6 (11.8)	83.4 (13.0)	83.0 (12.8)
Lifestyle behaviors			
Night sleep duration (daily), hour	8.6 (1.5)	8.3 (1.6)	8.4 (1.6)
Nap duration (daily), hour	0.4 (0.5)	0.5 (0.6)	0.5 (0.6)
Sitting time (daily), hour	3.1 (1.9)	3.5 (1.9)	3.4 (2.0)
Walking (weekly), MET-minutes	832.7 (1553.5)	1327.1 (1835.7)	1216.7 (1788.4)
MTVPA (weekly), MET-minutes	2811.7 (4468.8)	2675.3 (4175.6)	2705.7 (4243.1)
Blood measures			
Fasting glucose, mmol/L	5.6 (1.4)	5.5 (1.6)	5.5 (1.5)
Triglyceride, mmol/L	1.5 (1.3)	1.6 (1.2)	1.6 (1.3)
LDLC, mmol/L	2.4 (0.7)	2.6 (0.8)	2.6 (0.8)
HDLC, mmol/L	1.3 (0.3)	1.3 (0.3)	1.3 (0.3)
Total cholesterol, mmol/L	4.5 (0.9)	4.7 (0.9)	4.6 (0.9)
ALT, mmol/L	17.7 (15.0)	22.7 (19.8)	21.6 (18.9)
Creatinine, mmol/L	88.1 (18.9)	87.2 (19.4)	87.4 (19.3)
C-reaction protein, mmol/L	1.6 (3.3)	1.9 (4.3)	1.8 (4.1)
Uric acid, mmol/L	290.8 (132.1)	275.9 (98.4)	279.2 (107.0)

SD, standard deviation; BMI, body mass index; MTVPA, moderate-to-vigorous; LDLC, low-density lipoprotein cholesterol; HDLC, high-density lipoprotein cholesterol; ALT, alanine aminotransferase

Overall, the mean night sleep length was 8.4 h per-day, nap duration 0.5 h per-day and sitting time 3.4 h per-day. The average amount of walking during a week was 1216.7 MET-minutes, and MTVPA was 2705.7 MET-min. The descriptive measurements in rural and urban samples were also presented in Table 1.

The LCA analysis in the pooled population using the five lifestyle behavior variables resulted in the six-cluster model providing the best fit based on the lowest BIC and CAIC (Table 2). Participants generally displayed acceptable posterior probabilities for their assigned clusters. The mean posterior probabilities ranged from 0.53 to 0.73 across clusters. Only 6 participants (6/26093, 0.002%) showed their posterior probabilities low (≤ 0.3) across all six clusters.

Table 2: Statistical assessment of the optimal number of clusters from latent class analysis models based on lifestyle profiles including amount of physical activity (walking, moderate-to-vigorous physical activity), night sleep and nap duration, and sitting time

Model	*L^2 statistics*	*Number of parameters*	*BIC (based on L^2)*	*CAIC (based on L^2)*
1 cluster (H_0)	33193.9	45	-231699.2	-257747.2
2 cluster	31556.9	51	-233275.2	-259317.2
3 cluster	31079.0	57	-233692.1	-259728.1
4 cluster	30463.0	63	-234247.1	-260277.1
5 cluster	30248.3	69	-234400.8	-260424.8
6 cluster†	29891.1	75	-234696.9	-260714.9
7 cluster	29845.0	81	-234682.0	-260694.0

BIC (based on L^2), Bayes Information Criterion based on L-squared statistics. CAIC (based on L^2), Consistent Akaike's Information Criterion based on L-squared statistics. †The optimal model based on BIC and CAIC

Based on the optimal model (six-cluster-model), the mean length of night sleep duration in every cluster, which ranged from 8.9 (in cluster 5) to 8.0 (in cluster 6) hours per-day, reached the recommended amount of sleep for a health adult. Participants in cluster 3 did not spend time on napping, whereas the mean nap time ranged from 0.3 to 0.9 hours in the other clusters. Sitting duration was the longest in cluster 2 and was the shortest in cluster 5. Walking activities in clusters 1 (1685 MET-min) and 4 (4781.8 MET-min) far-excessed the minimum-amount, whereas the amounts in clusters 2, 3, 5 and 6 were only approximately one-third or less of the recommended minimum-level. For MOVPA, only one cluster (cluster 2) did not reach the minimum-level, while it was worth noting that in clusters 4 and 6 participants performed MOVPA as high as 8870 and 12814 MET-minutes respectively.

Fig. 1 shows the normalized features of lifestyle clusters. As the cluster with the largest size of participants, lifestyle parameters in cluster 1 were around means, which represented the most common pattern (45% of the total population) of lifestyle including night and nap sleep, sedentary time, and physical activity (separated by intensity i.e. walking and MOVPA). This common pattern was associated with a sufficient night and nap sleep duration, a long sitting time, and above recommended physical activities including both walking and MOVPA. The second most common pattern (24% of the total population) was featured by its long sitting time and lack of physical activities. The third cluster (13% of the total population) had a long night sleep time but no nap habit, and it was associated with a very low walking activity but sufficient MOVPA. The fourth cluster (8% of the total population) was featured by its high physical activities on both walking and MOVPA. The fifth cluster (6% of the total population) was associated with a long night sleep time, a short sitting duration and a low walking activity. The smallest cluster (cluster 6, 5% of the total population) was featured by its huge amount of MOVPA and limited amount of walking activity.

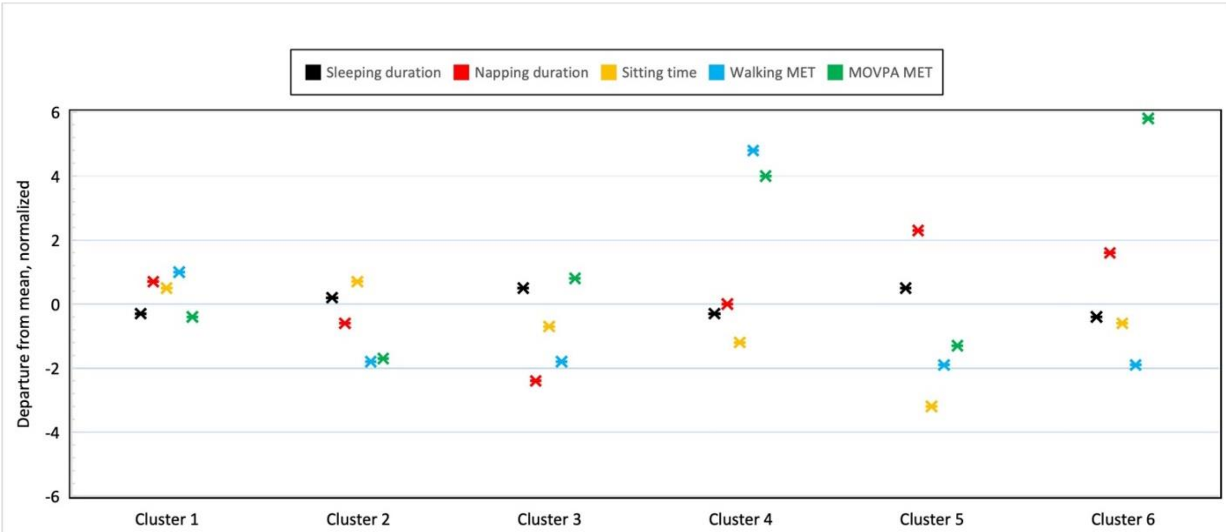

Fig. 1: Statistical normalized patterns of lifestyle activities according to clusters derived from latent class analysis MOVPA, moderate-to-vigorous physical activity; MET, metabolic equivalent of task

Difference in proportion of each cluster was presented between the urban and rural areas ($P<0.0001$). Higher proportions of clusters 2, 3 and 5 were observed in the urban population, suggesting the urban population had a longer night sleep duration, a lower amount of walking activity, and probably a lower amount of MOVPA, compared to participants living in the rural area.

Descriptive statistics with regard to several blood measures by LCA clusters are shown in Table 3. No obvious abnormal levels of blood measures were detected in any of the clusters.

Table 3: Participant characteristics by the lifestyle behavior clusters derived from the latent class analysis

Characteristics	***Cluster 1*** Mean (SD) or n (%)	***Cluster 2*** Mean (SD) or n (%)	***Cluster 3*** Mean (SD) or n (%)	***Cluster 4*** Mean (SD) or n (%)	***Cluster 5*** Mean (SD) or n (%)	***Cluster 6*** Mean (SD) or n (%)
Demographical and physical						
Age, year	52.7 (9.9)	50.3 (10.2)	49.3 (9.2)	49.1 (9.1)	52.8 (10.1)	48.9 (9.1)
Male, %	4429 (38.2)	2926 (47.1)	1286 (38.4)	948 (46.1)	661 (41.5)	660 (51.6)
Body mass index, kg/m²	24.9 (4.1)	24.7 (3.9)	24.4 (3.8)	24.5 (3.9)	24.7 (4.0)	24.2 (3.7)
Heart rate, per minute	74.1 (10.7)	74.1 (10.4)	74.1 (10.4)	73.5 (10.5)	75.4 (10.9)	73.9 (10.7)
Systolic blood pressure, mmHg	134.4 (22.4)	134.1 (21.6)	133.9 (21.5)	133.0 (21.0)	135.3 (22.3)	132.6 (20.1)
Diastolic blood pressure, mmHg	83.1 (12.1)	83.0 (12.1)	82.4 (13.8)	82.4 (12.0)	83.5 (12.1)	83.6 (19.6)
Blood measures						
Fasting glucose, mmol/L	5.6 (1.6)	5.5 (1.5)	5.3 (1.4)	5.4 (1.4)	5.5 (1.5)	5.4 (1.4)
Triglyceride, mmol/L	1.6 (1.2)	1.6 (1.3)	1.4 (1.2)	1.4 (1.3)	1.6 (1.2)	1.4 (1.2)

Low density lipoprotein cholesterol, mmol/L	2.6 (0.8)	2.6 (0.8)	2.5 (0.7)	2.5 (0.8)	2.5 (0.7)	2.4 (0.7)
High density lipoprotein cholesterol, mmol/L	1.4 (0.3)	1.3 (0.3)	1.3 (0.3)	1.4 (0.3)	1.4 (0.3)	1.4 (0.3)
Total cholesterol, mmol/L	4.7 (1.0)	4.6 (0.9)	4.5 (0.9)	4.5 (0.9)	4.5 (0.9)	4.5 (0.9)
Alanine aminotransferase, mmol/L	21.9 (17.5)	22.5 (24.3)	20.0 (15.9)	20.7 (15.6)	21.1 (16.3)	20.1 (16.2)
Creatinine, mmol/L	87.3 (17.8)	88.0 (24.4)	85.7 (15.9)	87.0 (17.0)	89.0 (17.1)	88.1 (17.7)
C-reaction protein, mmol/L	1.9 (3.7)	1.9 (4.3)	1.6 (4.0)	1.7 (4.9)	2.1 (5.3)	1.7 (4.3)
Uric acid, mmol/L	285.6 (97.9)	282.4 (109.0)	264.9 (126.9)	265.7 (90.0)	277.8 (124.3)	267.3 (114.2)

Discussion

This study demonstrated for the first time the common patterns of lifestyle in Chinese adults. The lifestyle parameters were obtained from the standard questions including sleep duration, sedentary time and physical activity by the optimal model. Six clusters were featured with their sizes ranging from 45%-5%. Difference in lifestyle patterns was observed between the urban and rural sites. Lifestyle-behaviors are influenced by cultural and social diversities (4; 5). The findings may serve as referent group for studying Chinese populations with regard to lifestyle behavior in other settings such as those living in other countries. For example, in Australia approximately 26% of the population born overseas, many are Chinese. It was found that compared to Anglo-Australian adolescents Chinese-Australian adolescents engaged in significantly less daily light and moderate-to-vigorous physical activities (5). However, it is unclear whether such difference is due to ethnical culture or other social factors.

Individual lifestyle parameters, such as physical activity, screen viewing time, night and nap sleep quality and quantity, have been more sufficiently described in Chinese populations. For example, a recent study found there remained a low prevalence of meeting MOVPA guidelines in Chinese adolescents (19). Another research investigated the association of physical activity, sedentary time, and sleep duration on the health-related quality of life among Chinese college-students, however, the relationships were analyzed separated on individual factors (20). It is necessary for the researchers to focus on particular factor to determine the relationship and evaluate the effect size of any association, however, understanding the common lifestyle patterns in general population is important since people are influenced by various lifestyle parameters as a package restricted within particular behavior cluster. However, no studies up to date described the common lifestyle behavior patterns in the Chinese population using LCA. Patterns of lifestyles were evaluated in Brazil female adolescents through LCA, where three clusters were derived namely "inactive and sedentary", "inactive and non-sedentary" and "active and sedentary" clusters, based on five factors including MOVPA, number of steps, screen time, sitting time and number of meals (9).

We presented several blood measures stratified by LCA clusters. However, only descriptive statistics was applied and there was no intension to implement any hypothesis-test as stratification causing the type-1 error. In the current study, no obvious abnormal levels of blood measures were detected in any of the lifestyle behavior clusters.

The large sample size enabled us to use LCA to separate the population into several clusters, with considerable size. This study was benefited by using two surveys in urban and rural, which increased its representativeness since in China 70% of the population lives in the rural or semi-urban areas and 30% in urban areas. It also enabled us to compare the lifestyle behaviors between these two geographically and social-economically different Chinese sites.

The study was limited by its cross-sectional design, therefore the longitudinal patterns or the associations with later health indicator, disease or morality need to be investigated in later phases of the research programme or in other independent studies with follow-up data. Self-reported data can be biased in many ways including recall bias and response bias. For the later bias, however, thanks to the high response rates in both surveys such systematic error was not likely to be large. Lifestyle behaviors such as sleep and physical activity were influenced by many factors including disease and social-demographic variables. Unfortunately, detailed morbidity and additional social-demographic variables were not available thus resulting a limitation, although the participants were randomly sampled subjects forming the general adult population within the study region. Night sleep duration was based on the hours between "going to bed" and "waking up", however, the actual sleep hours would be shorter and is dependent on individual persons, and the sleep quality was not measured. Misclassification may occur between physical activities according to intensity especially in a self-reported setting, which serves as another study limitation.

Conclusion

Our study, for the first time using LCA, described the six common lifestyle behavior patterns in the general adults of Chinese population. Further studies are required to confirm or question these patterns, and to investigate relationship of these patterns with health outcomes such as chronic diseases and mortality.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interest.

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