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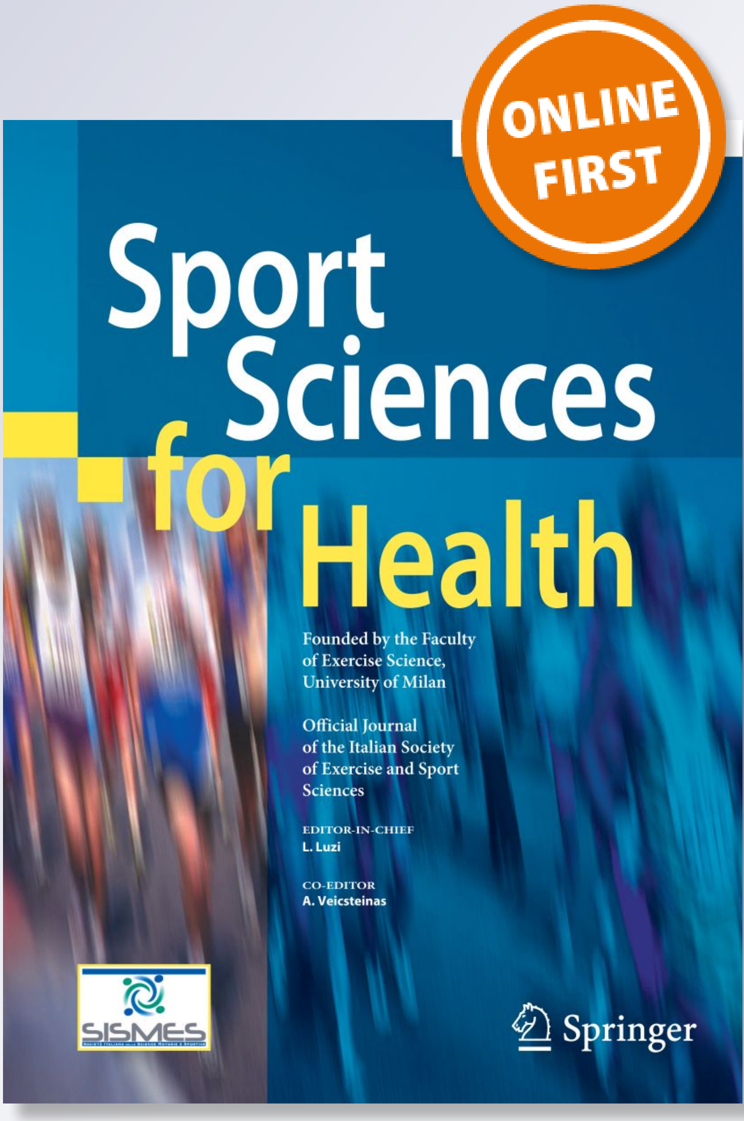

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ORIGINAL ARTICLE

A study of dividing the group by age of health-related fitness in Taiwan

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Abstract

The objective of this study was to find the optimal age in dividing the group in Taiwan. It used the 9660 health-related fitness data, in ages ranging from 25 to 49 years, including nine measurement indexes using systolic pressure, diastolic pressure, static heart rate, body height, body weight, 30-s sit-ups, 60-s sit-ups, sitting trunk flexion (sit and reach), and 3-min step test. This study was to find out the optimal age group by utilizing hierarchical clustering analysis and one-way ANOVA. The results show that the best way to divide male groups was by adopting the age ranges of 25–28 years, 29–32 years, 33–37 years, 38–46 years, and 47–49 years to groups 1–5, respectively. The female groups 1–5 was 25–28 years, 29–35 years, 36–41 years, 42–45 years, and 46–49 years, respectively.

Keywords Health-related fitness · Hierarchical clustering · One-way ANOVA

Introduction

Physical growth is controlled by genetic factors and the timetables of some harmonious routes [15]. Although the orders of growth and development of everyone are the same, there are significant individual differences in the speed and outcome of development. The cross section of age at adulthood has different interpretations for various physiological indicators. As age increases, muscle strength, softness, and cardiopulmonary function decline [6]. In terms of body composition, height is at a steady state; weight is affected by living habit and diet. The proportion of muscle and fat in weight is constantly changing throughout the life cycle. More specifically, in adulthood, changes in fat and muscle ratios are important factors affecting health [8]. Muscle performance reaches a peak between the age of 20 and 30 [14], and then, muscle strength and muscle endurance gradually decrease due to aging. In fact, as humans become elderly, muscle function declines [3]. Aoyagi and Shephard [2] point out that from 30 to 80 years old, muscle loss will be about 30–40%. Among them, the loss of muscle mass in the lower limbs is most apparent, while the loss of muscle mass results in a decrease in muscle strength. In addition, studies have also found that the number of muscle cells in adults older than 30 years old is lost at an average rate of 0.5% per year, and the number of muscle cells at the age of 90 has been lost by up to 70% [4, 12]. In terms of the cardiovascular system, a heart reaches mature size and rhythm at the age of 16 [10], the function of the circulatory system is reduced by the accumulation of cholesterol or lack of exercise, which further results in increase in blood pressure and heartbeat. The development of cardiorespiratory fitness also begins to peak around the age of 16 and gradually declines. After the age of 25, it experiences an average annual decline of about 1% [11].

A major feature of mature physiological indicators is slow change. For the cross section of age, different from the 1 year as a class interval of puberty, multiple years are used as a class interval. Therefore, for the age grouping of healthy physical fitness, the survey divided age groups into two groups in the "1999 National Physical Testing Project" of the Sports Administration, in the Taiwan Executive Yuan. The age of group 1 was between 6 and 19 years and 1 year was used as the interval; the age of group 2 was between 20 and 65 years, and 5 years was used as the interval. Moreover, the survey also divided age groups into two groups in 2001–2018: the age of group 1 was between 6 and 20 years,

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and 1 year was used as the interval; the age of group 2 was between 21 and 65 years, and 5 years was used as the interval.

In general, the body composition of males and females will change with age. During the aging process, the content of muscle and bone in the body will gradually decrease and the proportion of adipose tissue content will gradually increase [16]. A study by Janssen et al. [7] pointed out that because of the increase of age, males are significantly higher than females in the loss of muscle mass. The loss of muscle mass due to age increases with either males or females. The most obvious segmentation age is about 50 years [17]. Therefore, this study was divided into two groups, males and females, on the issue of dividing the group by age of health-related fitness.

Summarizing relevant research, the use of 5 years as the class interval of grouping conforms to the hypothesis of stable physiological indicators at adulthood. However, not all of the test items conform to such classification method. The excessively large difference between certain indicators in the same group may lead to the loss of important information; the lack of a significant difference in certain indicators in different groups may lead to the lack of value of grouping. It is worthy to use the results of test items to inversely deduce the class interval of grouping.

The purpose of this study was to find out the optimal age in dividing, using the 9660 national health physical fitness data (25–49 years old), with 9 measurement indicators [systolic blood pressure, diastolic blood pressure, static heart rate, body height, body weight, 30-s sit-ups, 60-s sit-ups, sitting trunk flexion (sit and reach), and 3-min step test].

Methods

Subjects

For the "National Physical Testing Project" of Ministry of Education Sports Department, Taiwan Executive Yuan, the investigated population was 6–65-year-old Taiwanese citizens with healthy body and living in various locations in Taiwan. The survey used stratified sampling as the sampling method to examine the data for population in various counties/cities in Taiwan and outlying islands stratified according to gender and age as determined by Ministry of the Interior. Moreover, the survey divided the population into 2 groups: group 1: citizens from age 6–20, with 1 year as the interval; group 2: citizens aged 21–65, with 5 years as the interval. The survey sampled a total of 50,000 citizens to test their physical fitness. This study selected and used the data from 3997 adult males and 5663 adult females in 25–49 years old, for a total of 9660 individuals.

Experimental design

According to the definition of age division provided by the Population Status Report in Taiwan of the Department of Accounting and Statistics, Taiwan Executive Yuan, the age of youth is 19–24 years, that of young adults is 25–49 years, and that of the middle-aged is 50–65 years. This study only used the data of young adult (25–49 years old) for subsequent research. First, this study observed the trend of standard scores of nine indicators. Second, this study used hierarchical cluster analysis to gradually combine various ages to form five clusters. Third, this study observed the differences in nine measurement items among these five clusters. This study used independent sample one-way ANOVA and post hoc comparison to investigate the absence/existence of differences in nine indicators of various age groups and determine the best grouping method.

This study divided nine indicators into three categories: category 1 was physiological indicators, including systolic blood pressure, diastolic blood pressure, and resting heart rate; category 2 was body-type indicators, including height and weight; category 3 was physical fitness indicators, including 30-s sit-ups (muscle strength), 60-s sit-ups (muscle endurance), sitting trunk flexion (softness), and 3-min step test (cardiorespiratory endurance indicator). Testing items and standards are in compliance with the rules of the American College of Sports Medicine (ACSM) [1].

Hierarchical cluster analysis

The main purpose of cluster analysis is to summarize similar variables or observed objects into a cluster. The standard for classification is entirely self-generated, namely, it is decided by data themselves [13]. Hierarchical cluster analysis is initiated from the observation that every observed object represents a cluster, and these clusters are gradually merged into large clusters. This study divided the data into five clusters and used Ward's Minimum Variance to merge them. The judgment criteria are as follows:

1. Semipartial *R*-square (SPRSQ): the incremental ratio of variance to total variance generated during the consolidation of two clusters [5]. If the value added at a certain step is relatively larger, the consolidation of clusters can be terminated.
2. RSQ: the ratio of between-cluster variance to total variance [5]. If the decrement value at a certain step is relatively larger, the consolidation of clusters can be terminated.

3. Cubic clustering criterion (CCC): the number of clusters referred to at the highest point of the region is the better number of clusters [5].
4. Pseudo F (PSF): the ratio of between-cluster variance mean square to within-cluster variance mean square [5]. The better number of clusters is judged according to the highest point of the region.

One-way ANOVA

This study used age class interval as the independent variable to perform the significance test on differences in nine measurement indicators (dependent variables), respectively. The experimental design was subject-based design (independent sample). Because the number of subjects was different, this study used post hoc comparison of Scheffe's method.

Date analyzing

This study used SAS 9.4 and SPSS 24 to analyze the Hierarchical cluster analysis, One-way ANOVA, and other descriptive statistics.

Result

Nine measurement indicators

Physiological indicators

To compare the differences in three indicators of various age groups, this study used the means and standard deviations of all age groups as the benchmarks, and then took the means of all age groups as the representative samples. Therefore, the average score of all age groups could be detected. Taking the systolic blood pressure chart showing 25-year-old adult males as an example, the mean and the standard deviation reading of all the adult males was 125.44 ± 1.54. The mean of systolic blood pressure of 25-year-old adult males was 125.9, and the mean standard score was 0.30. The comprehensive results of three indicators of all age groups are shown in Fig. 1 for adult male (the bold black vertical line in the figure uses 5 years as an interval) and Fig. 2 for adult female. For the adult male testes, the average systolic blood pressure and diastolic blood pressure went stable for the groups under 40 years old, but started to increase and reach the peak at approximately 44 (close to positive 2 standard deviations), and then became stable again. There was a trend of an increase in the heart rate of rest after 39 years old. For the adult female testes, both the systolic and diastolic blood pressure rose with age, those 45-year-old ones had the worst performance. Their resting heart rate did not rise with age,

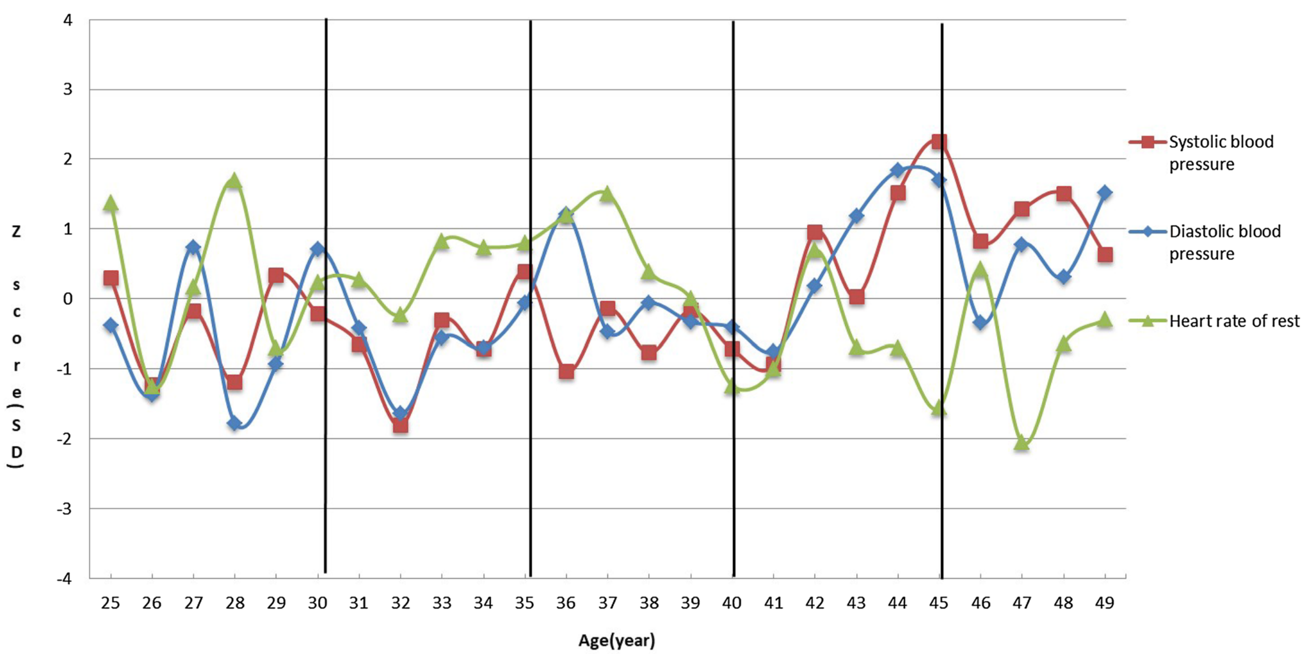


Fig. 1 Male physiological indicators

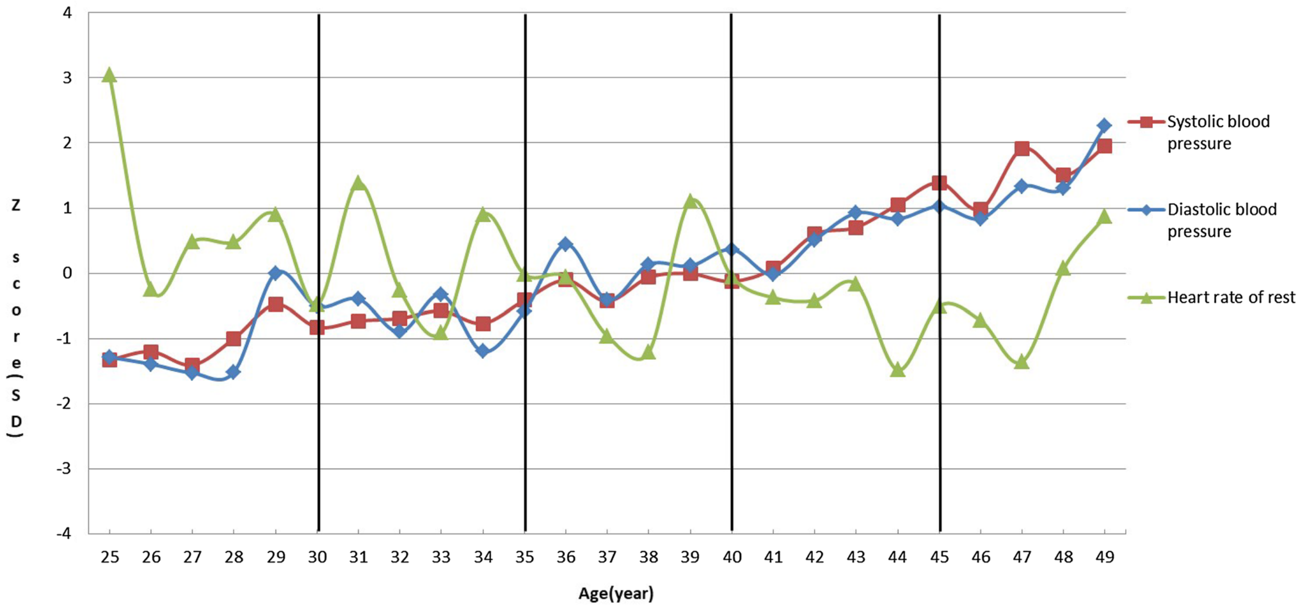


Fig. 2 Female physiological indicators

both positive and negative standard deviation between 2. In 47 years old, they have the lowest heart rate.

Body-type indicators

This study calculated the Pearson product–moment correlation coefficient between adult male's height and weight, and the correlation was 0.467. The height and weight are only moderate correlation results are expected, because the height of adulthood will hardly change, but the weight will rise continually. As shown in Fig. 3, the adult male's height significantly decreased from positive two standard deviations at 25 years old to negative two standard deviations at 49 years old. As shown in Fig. 4, the adult female's

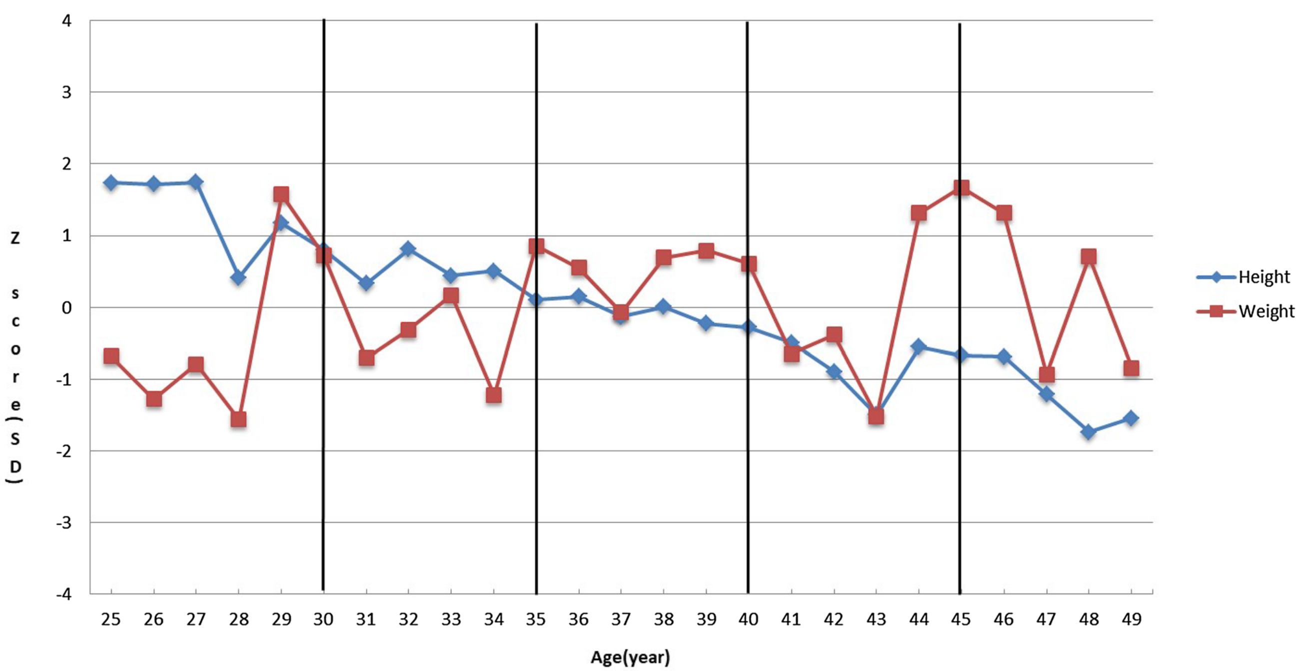


Fig. 3 Body-type indicators of males

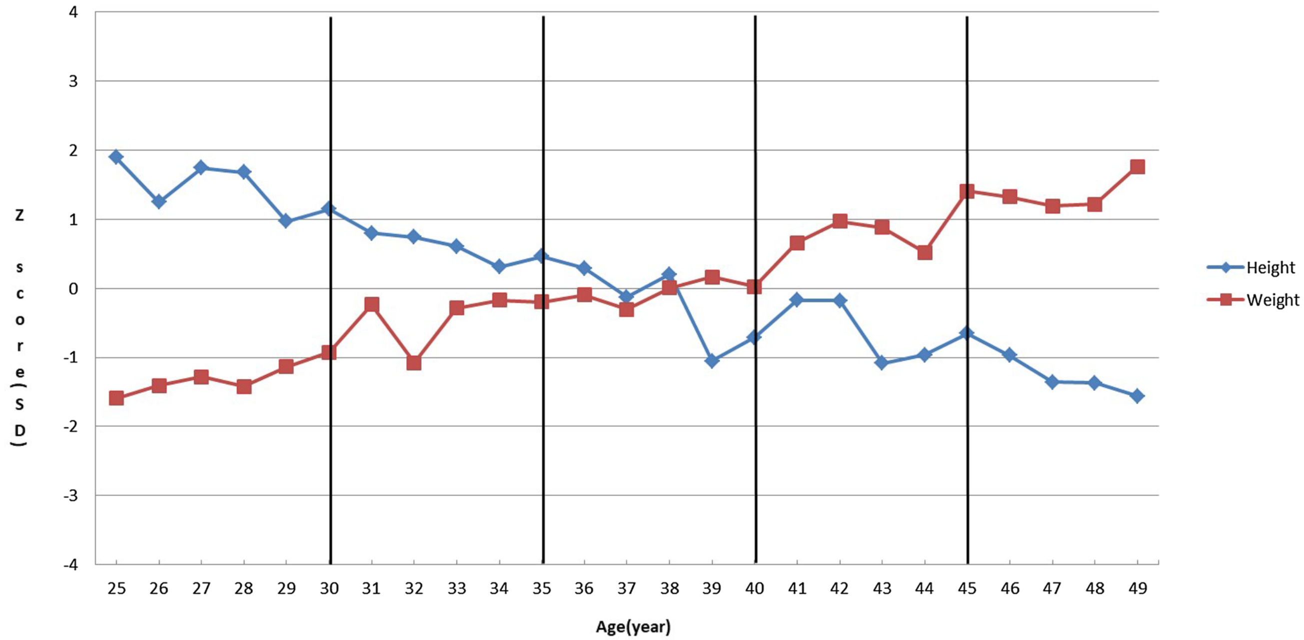


Fig. 4 Body-type indicators of females

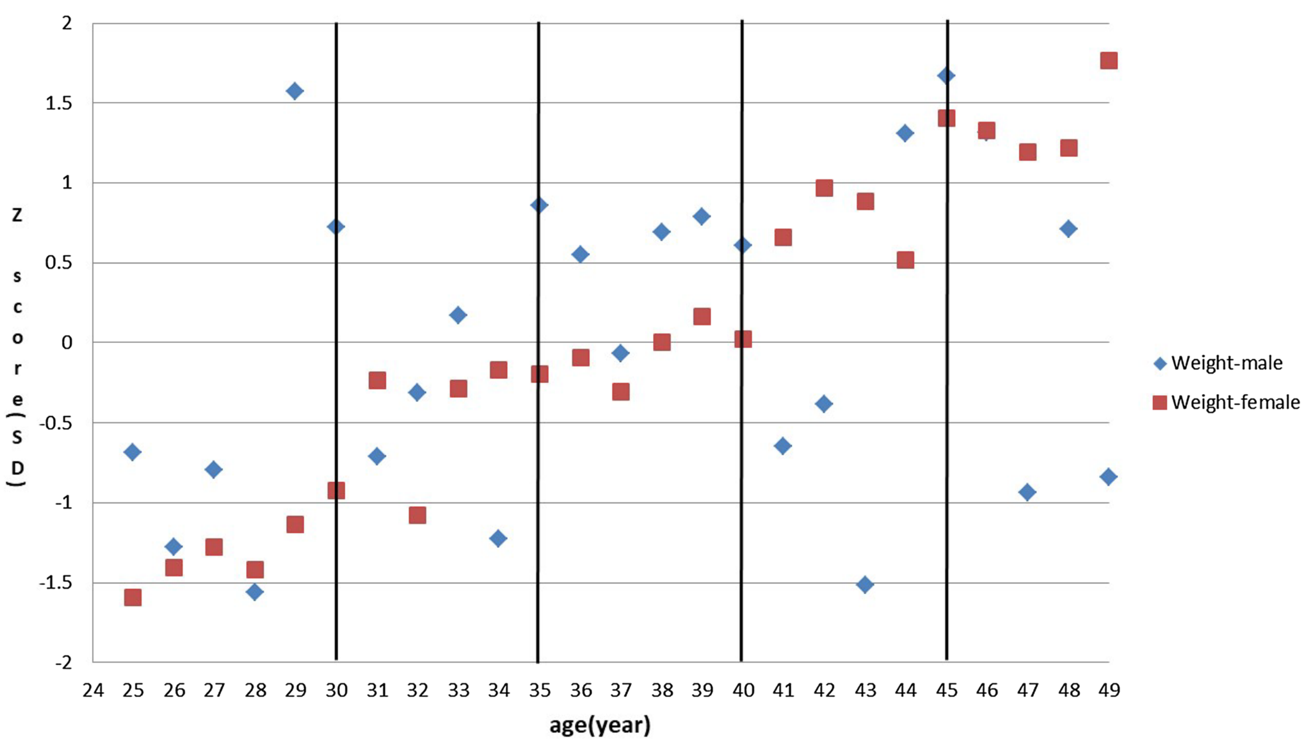


Fig. 5 Weight indicators of males and females

height dropped, from the standard deviation of two positive 25 years, down to 49 years of negative two standard deviation, 38–45 years less regular.

In Fig. 5, there was a trend of a slight increase in male weight. Their body weight stably increased in the 25–29 age range, became unstable from 30 to 34, then went stable again

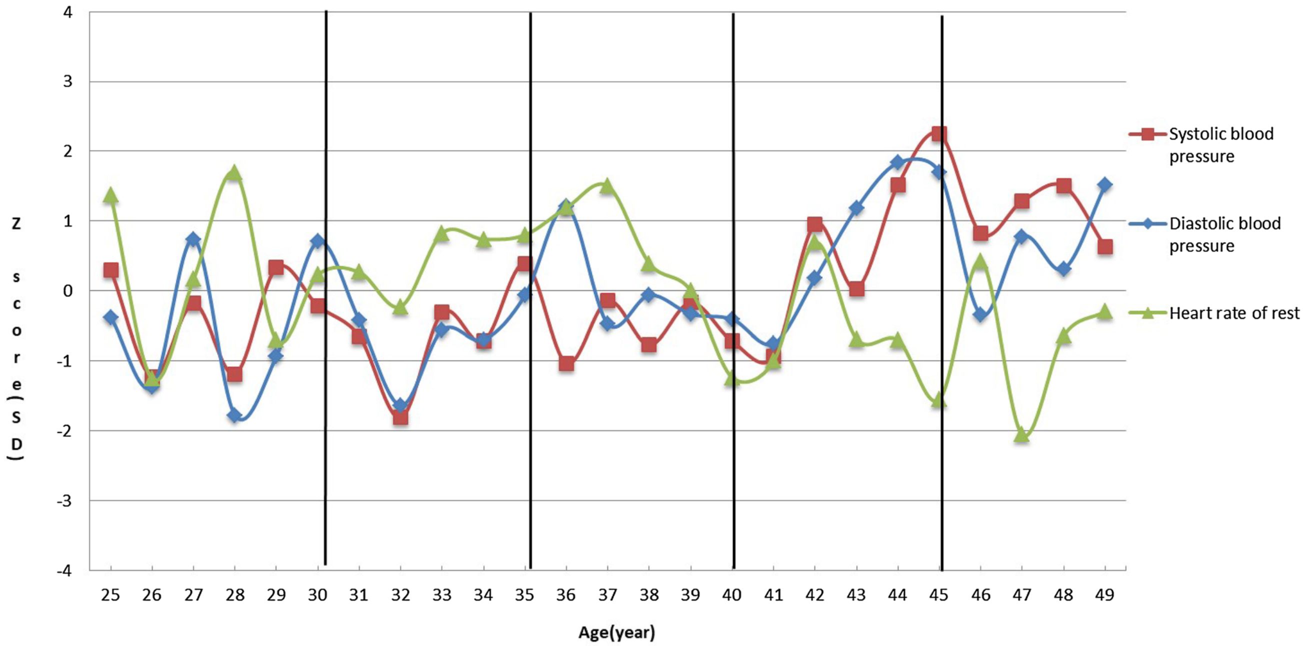


Fig. 6 Male physical fitness indicators

from 35 to 40, and eventually reached its peak after 44 years old. Their average body weight was steadily increasing since their 25-year-old notch, stably increasing to the 31-year-old node; after the 32-year-old point, it fell with a standard deviation of the mean; from 33 years old to 40 years old, it went steady again; and over 40, it gradually rose.

Physical fitness indicators

As shown in Fig. 6, the adult male test subjects underwent a significant physical fitness decrease in 30- and 60-s sit-ups from close to positive two standard deviations at 25 years old to close to negative two standard deviations at 49 years old. The readings constituted almost a set of overlapping images, suggesting that the correlation between 30- and 60-s sit-ups was very high. This study calculated the Pearson product–moment correlation, and found that the value was as high as 0.911, which suggested that there was a significant correlation. There was likewise a trend of a decrease in sitting trunk flexion. However, the trend was more irregular, and changed significantly after 40 years old. The 3-min step test was irregular but comparatively stable. Theoretically, there should be a trend of a significant decrease in 3-min step test. The cause of irregularity might be that the 3-min step test failed to clearly measure one's cardiorespiratory endurance in these circumstances.

Figure 7 shows that the adult female test subjects in 30-s and 60-s sit-ups had been on a d significant downward trend, from a 25-year-old node approaching two standard deviation to the 49-year-old average approaching two negative standard deviation; the two trendlines were almost completely overlapped. The sitting trunk flexion also showed a downward trend, but less regular. The forward curve also showed a downward trend, but less regular, 29-year-old to 35-year-old changes after the 40 years old also irregular, was the first rise and then decline. 3-min step test showed a more zigzagged trendline.

Age groups by cluster analysis

25–49-year-old adult males included a total of 25 observed subjects, and the number ranged from 1 to 24. In terms of the number of observed subjects after the consolidation of clusters, cluster 24 was the consolidation of 38 years old and 39 years old (as shown in Fig. 8). Therefore, there were two observed subjects; cluster 10 was the consolidation of 25 years old, 27 years old, and 28 years old, with a total of three observed subjects. Cluster 2 was the consolidation of 25 years old to 37 years old, with a total of 13 observed subjects. The judgment method of SPRSQ and RSQ criteria was to observe the change in criteria of various clusters. The clusters with a greater change were more suitable for grouping. The judgment method of CCC and PSF criteria was to observe the local extreme value of criteria of various clusters. The clusters with local extreme value were suitable for grouping. The observation on the four criteria of various clusters found that when the tested subjects were into two clusters, the change in two criteria, SPRSQ and RSQ, was the largest (SPRSQ 0.14 ~ 0.58, RSQ 0.58 ~ 0), and the two

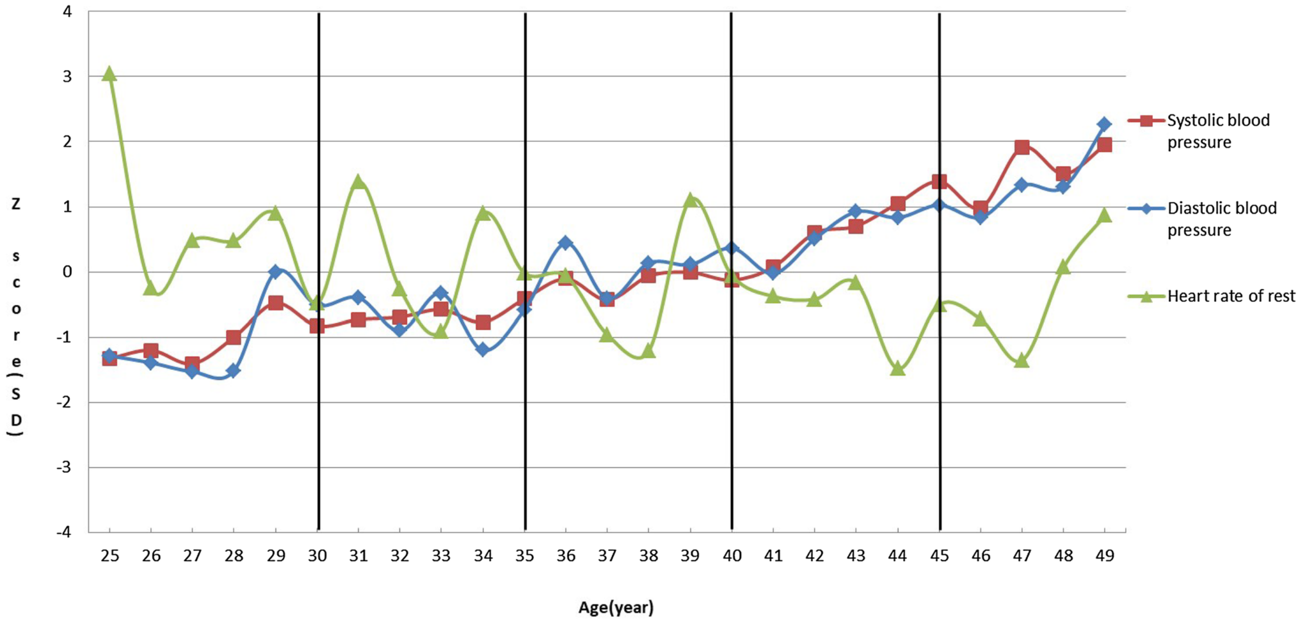
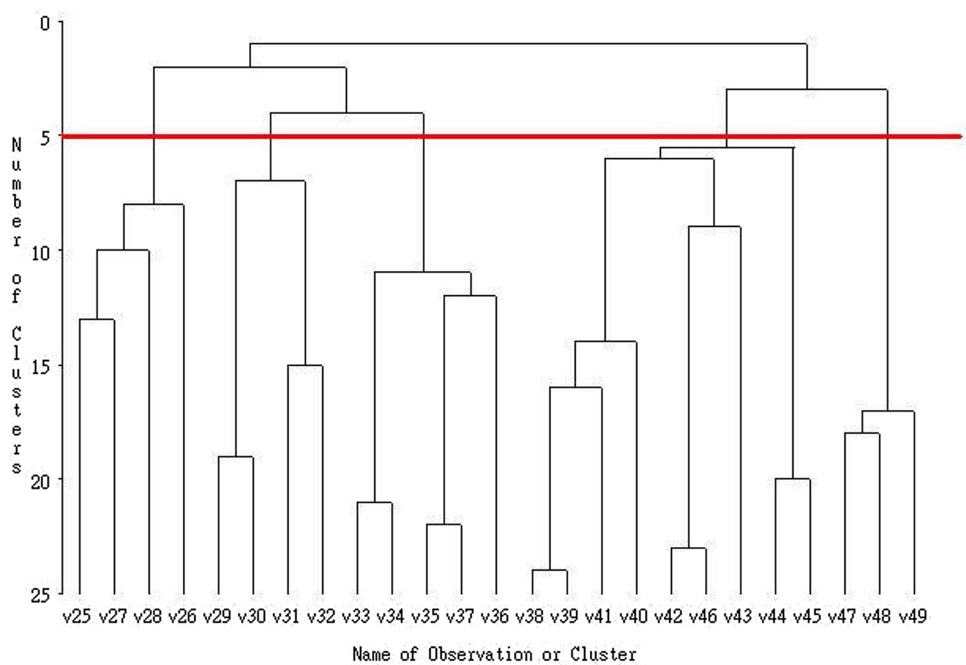


Fig. 7 Female physical fitness indicators

Fig. 8 Male age groups from the cluster analysis tree



criteria, CCC and PSF, had the highest local extreme values (CCC −0.94, PSF 31.4) when the tested subjects were divided into two clusters. Therefore, this research suggested that the best grouping method was to divide the tested subjects into two groups: 25–37 years old and 38–49 years old (Fig. 8, v25–v37: v38–v49).

Moreover, when the tested subjects were divided into five clusters, the criteria were: SPRSQ 0.01, RSQ 0.83, CCC −1.10, and PSF 23.90. The change in criteria, SPRSQ and RSQ, was of little significance. The criteria, CCC and PSF, had the local extreme values (when the population was divided into 4, 5, and 6 clusters). In other words, if the tested subjects were divided into 4–6 clusters, it is most appropriate to divide the tested subjects into 5 clusters. Therefore, the best five clusters are grouped in the first group of 25–28 years old, the second group of 29–32, the third group

Table 1 Male age groups by cluster analysis

Number of clusters	Merge observers	SPRSQ	RSQ	CCC	PSF
24	2	0.002	0.998	–	21.8
~	~	~	~	~	~
10	3	0.011	0.926	–	20.8
9	3	0.011	0.915	–	21.4
8	4	0.014	0.901	–	22.0
7	4	0.016	0.885	–	23.1
6	7	0.020	0.865	–	24.4
5	9	0.039	0.827	− 1.10	23.9
4	9	0.045	0.781	− 1.30	25.0
3	12	0.067	0.714	− 1.00	27.5
2	13	0.137	0.577	− 0.94	31.4
1	25	0.577	0	0	–

Table 2 Female age groups by cluster analysis

Number of clusters	Merge observers	SPRSQ	RSQ	CCC	PSF
24	2	0.001	0.99	–	24
~	~	~	~	~	~
6	4	0.013	0.90	–	32.90
5	7	0.015	0.88	− 0.99	37.20
4	8	0.041	0.84	− 1.00	36.80
3	11	0.060	0.78	− 1.00	39.00
2	17	0.142	0.64	− 0.89	40.00
1	25	0.639	0	0	–

of 33–37, the fourth group of 38–46, and the fifth from 47 to 49 (Table 1).

As shown in Table 2 and Fig. 9, this study merged two different datasets of female adults from 25 years old to 41 years old; a total of 17 tested subjects. SPRSQ and RSQ had the largest change when divided into two clusters (SPRSQ 0.142–0.639, RSQ 0.64–0). CCC and PSF also had the highest regional values in both clusters (CCC − 0.89; PSF 40.0). Therefore, the best cluster was judged as two groups, 25–41 years old and 42–49 years old (Fig. 9, v25 ~ v41: v42 ~ v49). However, as the basic assumptions in this study indicate, too few clusters in analysis should be avoided. Once the age range goes too wide, information of significant importance may well be missed. It is found from the cluster analysis that the best five clusters are grouped in the first group of 25–28 years old, the second group of 29–35 years old, the third group of 36–41 years old, and the fourth group of 42–45 years old, The fifth group is 46–49 years old in the female subject pool.

Nine indicators' ANOVA

The method of adult male age-class interval-based grouping was to divide the subject pool into the five following clusters: cluster 1: 25–28 years old, cluster 2: 29–32 years old, cluster 3: 33–37 years old, cluster 4: 38–46 years old, and cluster 5: 47–49 years old. The one-way ANOVA between the nine measurement indicators and five age groups were summarized, as shown in Table 3. The results showed that analysis based on weight only did not reach the traditional level of significance (α value = 0.05), and there was no distinct difference amongst groups. Other measurement indicators all reached statistical significance, suggesting that there

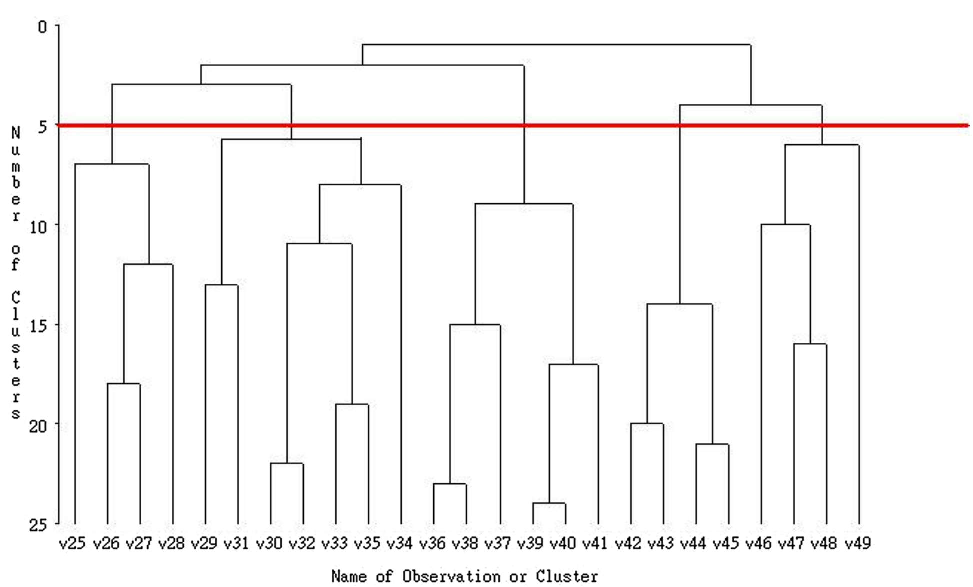


Fig. 9 Female age group from the cluster analysis tree

Table 3 Male nine indicators ANOVA

Indicators	Resource	SS	*df*	MS	*F* value
Systolic blood pressure	Between groups	26,850.08	4	6712.52	29.81*
	Within groups	898,871.49	3992	225.17	
	Total	925,721.57	3996		
Diastolic blood pressure	Between groups	17,340.50	4	4335.13	25.51*
	Within groups	678,533.03	3992	169.97	
	Total	695,873.53	3996		
Heart rate of rest	Between groups	20,640.67	4	5160.25	28.99*
	Within groups	710,514.53	3992	177.99	
	Total	731,155.2	3996		
Height	Between groups	0.95	4	0.24	60.00*
	Within groups	15.18	3992	0.004	
	Total	16.13	3996		
Weight	Between groups	8045.50	4	2011.13	19.05
	Within groups	421,477.61	3992	105.58	
	Total	429,523.11	3996		
30-s sit-ups	Between groups	16,678.724	4	4169.68	183.13*
	Within groups	90,893.98	3992	22.77	
	Total	107,572.70	3996		
60-s sit-ups	Between groups	54,870.030	4	13,717.51	209.56*
	Within groups	261,305.44	3992	65.46	
	Total	316,175.47	3996		
Sitting trunk flexion	Between groups	48,460.11	4	1211.53	8.99*
	Within groups	538,133.36	3992	134.80	
	Total	586,593.47	3996		
3-min step test	Between groups	11,990.25	4	2997.56	28.15*
	Within groups	419,038.29	3935	106.49	
	Total	431,028.54	3939		

$^*p < 0.05$

were inter-group differences. Post hoc comparisons had to be performed to acquire findings for such inter-group differences. This study used Scheffe's method to conduct the post hoc test, because the number of people in each group might be different. The comparison results showed that there was no between-group difference in systolic blood pressure, diastolic blood pressure, heart rate of rest, weight, and 3-min step test. However, there were significant differences in height, 30-s sit-ups, and 60-s sit-ups. Moreover, there was a difference in sitting trunk flexion between group 1 and group 4, group 1 and group 5, group 2 and group 5, and group 3 and group 5.

Likewise, the method of adult female age-class interval-based grouping was to divide the subject pool into the five following clusters: cluster 1: 25–28 years old, cluster 2: 29–35 years old, cluster 3: 36–41 years old, cluster 4: 42–45 years old, and cluster 5: 46–49 years old. The one-way ANOVA between the nine measurement indicators and five age groups were summarized, as shown in Table 4. The results showed that only 3-min step test did not reach the traditional level of significance (α value = 0.05). The comparison results showed that there was no inter-group difference in systolic blood pressure, diastolic blood pressure, 30-s sit-ups, and 60-s sit-ups. The comparison results showed that there was no between-group difference in heart rate of rest, sitting trunk flexion, and 3-min step test.

There were no differences between the clusters as far as indexes of heart rate of rest, sitting trunk flexion were concerned. Reference ranges for variance analysis did reach the level of significance in sitting trunk flexion between group 1 and group 4, group 1 and group 5, group 2 and group 5, and group 3 and group 5. As far as body height was concerned, no clear difference emerged except for the group 3 and the group 4. The rest of the groups made a difference, and body weight also varied with distinction in the fourth group. There was no overall difference among the five groups, but for the remaining groups, differences of significance did exist.

The results of the variance analysis showed that five clusters using cluster analysis could obtain the most consistent results regarding nine measurement indicators and five age groups. In other words, the best situation was the absence/existence of differences in all nine indicators. Moreover,

Table 4 Female nine indicators ANOVA

Indicators	Resource	SS	*df*	MS	*F* value
Systolic blood pressure	Between groups	82,388.38	4	20,597.09	89.38*
	Within groups	1,303,879.31	5658	230.45	
	Total	1,386,267.69	5662		
Diastolic blood pressure	Between groups	22,007.20	4	5501.80	40.36*
	Within groups	771,174.54	5657	136.32	
	Total	793,181.73	5661		
Heart rate of rest	Between groups	1446.40	4	361.60	2.71
	Within groups	753,821.16	5658	133.23	
	Total	755,267.56	5662		
Height	Between groups	0.5	4	0.16	54.70*
	Within groups	16.42	5658	2.903E−03	
	Total	17.06	5662		
Weight	Between groups	13,368.96	4	3342.24	52.32*
	Within groups	361,414.34	5658	63.88	
	Total	374,783.31	5662		
30-s sit-ups	Between groups	11,423.43	4	2855.86	122.76*
	Within groups	131,628.16	5658	23.26	
	Total	143,051.59	5662		
60-s sit-ups	Between groups	37,419.80	4	9354.95	127.76*
	Within groups	414,286.83	5658	73.22	
	Total	451,706.63	5662		
Sitting trunk flexion	Between groups	1693.335	4	423.33	3.25
	Within groups	736,651.88	5658	130.20	
	Total	738,345.22	5662		
3-min step test	Between groups	124.519	4	31.13	0.28
	Within groups	605,661.62	5548	109.17	
	Total	605,786.14	5552		

*$p < 0.05$

because the sample size was large, it was easy to reach a meaningful level of significance [9]. For the ability of independent variables to explain the correlation strength ($\hat{\omega}^2$) of dependent variables, the correlation strength of nine measurement indicators was 2.97%, 2.54%, 2.90%, 5.86%, 19.03%, 15.50%, 17.35%, 8.92%, and 2.85%, respectively. The variable with the largest variance indications was weight, and that with the smallest variance indications was diastolic blood pressure. However, none of them exceeded 20%. Although there were statically significant differences, the practical values were low and could be used for reference only (Table 5).

Conclusion

For the statistical cluster analysis, this study suggested that the best choice is to divide the subject pool into two clusters. However, in terms of practical application, an excessively large within-group age difference would lead to the loss of age representativeness and the loss of too much information from physiological indicators. It was effective to divide the observations into homogeneous and distinct groups. Taking the two clusters of this study as an example, 25-year-old and 37-year-old subjects were placed in a group. Was the gradual decrease in muscle performance due to aging seemingly reasonable? Wouldn't the blood pressure and heartbeat of cardiovascular system be affected by the increase in age? Wouldn't the accumulation of cholesterol or lack of exercise lead to reduced function and further lead to the increase in blood pressure and heartbeat? There were significant differences in physiological indicators or physical fitness indicators within a 12-year range (25–37 years old), so they should not be placed in the same group. The basic assumption of this study was to divide the observed population into five clusters. According to the theoretical basis, choosing 5-year class intervals to group the ages of this population is the most frequently used grouping strategy in various studies/surveys concerning age class interval. The main reason for such a method is also to prevent the excessively small number of clusters from leading to excessively large within-group age difference and the loss of important information.

Table 5 Age groups' post hoc comparison

Index	Age group	Male				Female			
		Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
Systolic blood pressure	Group 1	0.02	− 0.29	− 1.59	− 2.57	− 2.40*	− 4.49*	− 8.51*	− 12.08*
	Group 2		− 0.31	− 1.61	− 2.59		− 2.09*	− 6.11*	− 9.69*
	Group 3			− 1.29	− 2.28			− 4.02*	− 7.59*
	Group 4				− 0.99				− 3.57*
Diastolic blood pressure	Group 1	− 0.20	− 1.05	− 1.56	− 2.18	− 1.96*	− 3.35*	− 4.85*	− 6.68*
	Group 2		− 0.85	− 1.35	− 1.98		− 1.40*	− 2.89*	− 4.73*
	Group 3			− 0.50	− 1.13			− 1.49*	− 3.33*
	Group 4				− 0.63				− 1.84*
Heart rate of rest	Group 1	0.03	− 0.28	1.23	1.63	0.90	1.35	1.72	1.43
	Group 2		− 0.58	0.93	1.34		0.45	0.83	0.53
	Group 3			1.51	1.92			0.38	0.08
	Group 4				0.40				− 0.30
Height	Group 1	0.01*	0.02*	0.03*	0.05*	0.01*	0.02*	0.03*	0.04*
	Group 2		0.01*	0.02*	0.03*		0.01*	0.02*	0.02*
	Group 3			0.01*	0.02*			0.005	0.01*
	Group 4				0.01*				0.009*
Weight	Group 1	− 0.95	− 1.49	− 1.23	− 0.62	− 1.42*	− 2.37*	− 4.06*	− 4.89*
	Group 2		-0.54	− 0.28	0.34		− 0.95*	− 2.64*	− 3.47*
	Group 3			0.26	0.88			− 1.68*	− 2.52*
	Group 4				0.61				− 0.83
30-s sit-ups	Group 1	2.55*	3.99*	5.16*	7.11*	1.64*	2.56*	3.60*	4.92*
	Group 2		1.44*	2.61*	4.56*		0.92*	1.96*	3.28*
	Group 3			1.17*	3.12*			1.04*	2.36*
	Group 4				1.95*				1.32*
60-s sit-ups	Group 1	4.49*	7.17*	9.43*	12.63*	2.87*	4.66*	6.67*	8.74*
	Group 2		2.68*	4.93*	8.13*		1.79*	3.80*	5.88*
	Group 3			2.26*	5.46*			2.01*	4.08*
	Group 4				3.20*				2.07*
Sitting trunk flexion	Group 1	1.45	1.75	2.18*	4.20*	0.03	1.01	0.84	1.53
	Group 2		0.31	0.73	2.75*		0.99	0.81	1.50
	Group 3			0.43	2.44*			− 0.18	0.51
	Group 4				2.02				0.69
3-min step test	Group 1	− 0.32	− 0.59	− 1.28	− 0.88	− 0.12	− 0.31	− 0.11	0.14
	Group 2		− .28	− 0.97	− 0.56		− 0.18	0.01	0.27
	Group 3			− 0.69	− 0.28			0.20	0.45
	Group 4				0.40				0.25

*$p < 0.05$

Therefore, this study decided to give up the best age grouping method—to divide the population into two clusters: 25–37 years old and 38–49 years old, and adopted the second best method—to divide the population into five clusters for the male, including cluster 1: 25–28 years old, cluster 2: 29–32 years old, cluster 3: 33–37 years old; cluster 4: 38–46 years old, and cluster 5: 47–49 years old. And to divide the population into five clusters for the female, including cluster 1: 25–28 years old, cluster 2: 29–35 years old, cluster 3: 36–41 years old; cluster 4: 41–45 years old, and cluster 5: 46–49 years old.

The age class interval was determined by the similarity/difference in measurement indicators and was not fixed. The purpose of this study is to find out the best age class interval. This study used 5-year class intervals of healthy physical fitness at adulthood as the theoretical basis, namely, the purpose is to divide the population into five age groups. First, this study observed the trend of standard score of nine indicators in various age groups. Second, this study used hierarchical cluster analysis to gradually merge age groups to form five homogeneous clusters. Third, this study observed the differences in nine measurement indicators of these five clusters and used independent sample one-way ANOVA and post hoc comparison to test the differences in nine physiological indicators of the five age groups. According to the grouping results, the absence/existence of differences in all nine indicators could cause the nine physiological indicators to achieve the most consistent performance in various age class intervals. Therefore, it was judged as the best grouping method.

The research results showed that the cluster analysis concerning internal data and explicit variance analysis could be used as the judgment basis for age class interval. The best age class interval for male was: group 1: 25–28 years old, group 2: 29–32 years old, group 3: 33–37 years old, group 4: 38–46 years old, and group 5: 47–49 years old. And the best age class interval for female was: group 1: 25–28 years old, group 2: 29–35 years old, group 3: 36–41 years old, group 4: 42–45 years old, and group 5: 46–49 years old.

At last, the limitation of this study is that although the sampling process goes in accordance with effective sampling methods, the one-off data collection lacks long-term rolling corrections. This study was experimental; the conclusion cannot be analogized to the practical general survey.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Written informed consent was obtained from all individual participants included in the original study.

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