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EFFECT OF A 12-WEEK PILATES COURSE ON BODY COMPOSITION AND CARDIOPULMONARY FITNESS OF ADULTS LIVING IN AN URBAN COMMUNITY

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ABSTRACT

Engagement in regular physical activity is helpful in enhancing physical fitness, which greatly outweighs the potential risks involved. Pilates is a non-contact physical activity, as it involves no physical contact with other people. Pilates is considered a relatively safe physical activity. The purpose of the present study was to explore the effect of the Polestar^{TM} Pilates method of exercise on the body composition and cardiopulmonary fitness of adults. The design of the study was quasi-experimental. The experimental group comprised 53 participants (44 females, 9 males). The control group consisted of 35 participants (31 females, 4 males). Only the experimental group received Polestar^{TM} Pilates exercise training, which was presented by a certified Pilates trainer. Both groups received a pre- and post-test of body composition and cardiopulmonary fitness. After 12 weeks of Pilates training, the cardiopulmonary fitness of the experimental group was significantly enhanced ($p<0.05$), but changes in body composition were not statistically significant. For future research, it is recommended that continuous tracking for 3 to 6 months at the end of the intervention period to follow up the intervention effect be included in the research design. Longitudinal research can provide a greater understanding of the potential long-term benefits of cardiopulmonary fitness and body composition.

Key words: Body fat percentage; Cardiopulmonary fitness; Pilates exercise.

INTRODUCTION

Improvements in the material living standards of numerous communities are associated with an increased incidence of the problem of obesity (O'Brien & Dixon, 2002; Abdul-Rahim *et al.*, 2003). Abdul-Rahim e*t al.* (2003) indicate that the prevalence of obesity in urban communities was higher than rural communities. A person's fat mass or body fat percentage has been the most important estimate of health because of its strong correlation with cardiovascular diseases (Yasumura *et al.*, 2000; Heyward & Wagner, 2004). Body composition refers to the assessment of absolute and relative amounts of bone, muscle and fat mass as measured by different methods depending on the technology at hand, such as skin fold callipers, hydrostatic weighing, Dual-emission X-ray absorptiometry (Aladro-Gonzalvo *et al.,* 2012).

In addition, cardiopulmonary fitness refers to the capability of the body's overall oxygen supply system. Studies have shown that cardiopulmonary endurance gradually decreases by approximately 1% annually after the age of 25 years (McArdle *et al.,*1991). To improve a person's cardiopulmonary fitness, an appropriate intensity of exercise is needed in order to promote cardiovascular circulation, neuromuscular coordination, energy metabolism and pulmonary ventilation, and other physiological functions (Osullivan & Schmitz, 2001).

Regular exercise can improve physical fitness (Finch *et al.,* 2001), but the more intense the exercise the more injury will occur (Finch & Cassell, 2006). Researchers continue to investigate new exercise techniques where the injury risk of the musculoskeletal system is minimised and is a relatively safe exercise that could affect body composition and cardiopulmonary fitness in humans (Wells *et al.,* 2012). Although the Pilates exercises developed by Joseph Pilates in the early 1930s were not aimed primarily at the control or modification of body composition and cardiopulmonary fitness, his method has recently become popular (Aladro-Gonzalvo *et al.,* 2012).

Pilates designed a comprehensive method of muscle stretching and strengthening, with the goal of building a strong body and with the philosophy of 'mind controls body'. According to its founder, the Pilates program should incorporate the use of special apparatus and equipment in movement routines designed to enhance flexibility, strength and coordination between breathing and movement (Pilates, 1934, 1945). Pilates is advocated as a beneficial exercise method for adult populations (Stanko, 2002; Muscolino & Cipriani, 2003).

Studies investigating the effect of Pilates exercises on body composition and cardiopulmonary fitness have been sparse and the empirical evidence to date has been inconsistent. One study found that for body composition, fat content in the limbs and overall body was reduced after following Pilates exercises (Baltaci *et al.,* 2005). Another study reported no change in total body mass (Rogers & Gibson, 2006), while yet another study showed similar results, with an additional increase in lean mass (Carvalho *et al.,* 2009).

For cardiopulmonary fitness, one study indicated that the increase in heart rate during Pilates exercise did not reach an appropriate target range (Schroeder *et al.,* 2002). Another study showed that engagement in Pilates for four weeks had no significant effect on the participants' systolic and diastolic blood pressure (Jago *et al.,* 2006). Although Pilates proponents claim that the program improves heart and lung function by enhancing respiratory efficiency, the scientific literature to date does not support this argument. Thus, the possible effects of Pilates on adult cardiopulmonary fitness require further exploration.

PURPOSE OF THE STUDY

Pilate's exercises have been shown to benefit physiological, psychological and motor function (Lange *et al.,* 2000; Bernardo & Nagle, 2006; Bernardo, 2007). However, these findings might be queried because of methodological weaknesses. Possible methodological issues include small sample sizes, the lack of experimental research designs and poor validity or reliability of measurement instruments (Aladro-Gonzalvo *et al.*, 2012). The present study thus used a quasi-experimental design to investigate the effects of the Polestar Pilates method in adults living in an urban community. The effects of a Pilates exercise program on the body composition and cardiopulmonary fitness of a group of adult participants were investigated.

METHODOLOGY

Participants

The participants were all selected from the staff and volunteers drawn from 6 community institutions and were residents of Taipei City, Taiwan. Participants were excluded if the physicians found them unsuitable (osteoporosis, joint replacement, patellofemoral pain syndrome) for this study. The final sample comprised 125 participants aged between 20 and 65 years, who had not previously been exposed to Pilates training. The study protocol was reviewed and approved by the Human Research Ethics Committee, National Taipei University of Nursing and Health Sciences.

Design

Participants were asked to sign a consent form and were informed not to change their own habits of exercise and activities within their daily living during the duration of the research process. Participants were assigned to the 2 groups according to their preference, with 72 participants electing to be in the experimental group and 53 in the control group. The research design was thus quasi-experimental and no randomisation was used.

All participants engaged in a body composition and cardiopulmonary fitness pre-test, one week prior to the intervention. The experimental group received Pilates exercise training (60 minutes per session, twice a week for 12 consecutive weeks), and the control group received no exercise intervention whatsoever, although they may have been participating in their own exercise routines outside of the study setting. The testing settings were the same for both groups. Exercise was scheduled after work to suit the needs of the respective institutions. The experimental group participants attended the exercise classes at their respective institutions to facilitate their attendance at classes. Post-tests were conducted within 1 week after the 12-week intervention had ended, and testing was conducted in the same locations.

Measurements

Body composition

The principle of Bioelectric Impedance Analysis (BIA) was adopted. BIA is a widely used method for estimating body composition. The technology is relatively simple, quick, very limited between observer variations and non-invasive. BIA works well in healthy subjects and chronic diseases with a validated BIA equation that is appropriate with regard to age, gender and race (Norman *et al.*, 2012). The InBody 230 (Body composition analyser, Biospace Co., Ltd.), was used to measure body composition and record the body fat percentage.

Cardiopulmonary fitness (Watkins, 1984; Andrade *et al.*, 2012)

The 3-minute step-test was conducted to measure each participant's pulse 3 times and calculate a cardiopulmonary fitness index to reflect cardiopulmonary endurance. The assessor set a stopwatch to 3 minutes, and participants were asked to stand facing a wooden box that was 35cm high. Participants then stepped up and down rhythmically at a frequency of 96 beats per minute, thus comprising 24 steps up and down per minute. They were instructed to stop the step-test immediately if they experienced discomfort. All participants had stopwatches and stopped them if they ceased the step test to record their actual exercise time. After completing the 3-minute test, participants were requested to measure their pulse recovery rates between 1 and 1.5 minutes after ceasing the exercise; again at between 2 and 2.5 minutes after exercise; and for a final time between 3 and 3.5 minutes. All these measurements were obtained in a sitting position. The 3 pulse rates were used in an equation to calculate an index of step cardiopulmonary function, as follows (Gallagher & Brouha, 1943; Liu & Lin, 2007):

$$\text{Index}=\frac{Duration(\text{sec})}{2(A+B+C)} \text{ x } 100$$

where A = recovery heart beat counts within 1 to 1.5 minutes,
B = recovery heart beat counts within 2 to 2.5 minutes, and
C = recovery heart beat counts within 3 to 3.5 minutes after stepping exercise.

Exercise intervention program

Polestar Pilates principles and the Pilates Group Mat Exercise Intervention Program were conducted for 60 minutes at each session, twice a week for 12 consecutive weeks (Otto *et al.*, 2004). The number of participants per class was limited to 12 people. The classes were conducted by a qualified trainer with Polestar Pilates certification and supervised by a qualified physical therapist that also had Polestar Pilates certification. Their presence was aimed at ensuring the accuracy of the exercises performed by the participants during the exercise program implementation (to follow, *Pilates Exercise Program*).

Data analysis and statistics

Data were processed and analysed using the SPSS 17.0 statistical software package for Windows. The level of statistical significance for all tests was set at $p<0.05$. Descriptive statistical analysis was conducted to calculate the percentages, means and standard deviations of relevant data. Inferential statistical analysis included the chi-square test and independent-sample t-test to compare the performance of the experimental and the control groups. A homogeneity test was conducted where the differences between the pre-test scores of the 2 groups were determined. Thereafter, the paired t-test was used to analyse the effectiveness of the exercise program by comparing pre- and post-intervention results for the experimental group and control group separately. Using the pre-tests of the 2 groups as the covariates, ANCOVA was conducted to determine the post-test differences between the 2 groups.

Test-retest reliability

The same assessor tested the 20 participants twice (one week apart). These results were used to calculate test-retest reliability by means of a correlation coefficient for the 2 measurements.

The mean for body fat percentage was 28.7% (±5.4) for the first measurement and 29.8% (±5.6) for the second, and the correlation coefficient between the 2 measurements was r=0.969 (p<0.01). For the heart rate measurements (reflecting cardiopulmonary fitness), the mean cardiopulmonary fitness index was 62.8±10.4 at the first measurement and 59.1±7.8 at the second. The correlation coefficient for the relationship between the 2 measurements was r= 0.703 (p<0.01).

PILATES EXERCISE PROGRAM

Exercise	Repetitions /duration	Progression
1. Supine breathing	5 minutes	Weeks 1-12
2. Pelvic clock	5 minutes	Weeks 1-4
3. Femur arcs	6 repetitions on each side	Weeks 1-4
4. Basic bridging	6-8 repetitions	Weeks 1-8
5. Assisted roll up	6 repetitions	Weeks 1-4
6. Quadruped series	6-8 repetitions	Weeks 1-8
7. Prone press up	6 repetitions	Weeks 1-4
8. Femur circles	6 repetitions in each direction	Weeks 1-4
9. Side-lying series	3-6 repetitions on each side	Weeks 1-4
10. Hundred	1 set	Weeks 4-12
11. Single leg stretch	3-6 repetitions on each side	Weeks 4-8
12. Roll up	6-8 repetitions	Weeks 4-8
13. Rolling like a ball	6-8 repetitions	Weeks 4-8
14. Swan Dive I & II	3-6 repetitions	Weeks 4-8
15. Single leg kick	6-8 repetitions	Weeks 4-8
16. Leg circles	3-6 repetitions in each direction	Weeks 4-12
17. Sidekick	6 repetitions in each direction	Weeks 4-12
18. Spine stretch	6-8 repetitions	Weeks 4-12
19. Spine twist	6-8 repetitions	Weeks 4-12
20. Mermaid	3-6 repetitions in each direction	Weeks 4-8
21. Standing balance with hip flexion	4 repetitions in each side / each direction	Weeks 4-12
22. Standing balance with hip extension	4 repetitions in each side / each direction	Weeks 4-12
23. Single straight leg stretch	6-8 repetitions	Weeks 8-12
24. Swimming	3-6 sets	Weeks 8-12
25. Push up	3-6 repetitions	Weeks 8-12
26. Leg pull	3-6 repetitions	Weeks 8-12
27. Leg pull front	3-6 repetitions	Weeks 8-12

RESULTS

Demographic characteristics

Of the 72 people in the experimental group, 9 participants did not complete the study. Of the 9 participants, 1 had shoulder pain, 1 sprained an ankle, 1 was pregnant, 4 moved home or changed working hours, and 2 were unable to continue participating because of family reasons.

***TABLE 1*: DESCRIPTION OF DEMOGRAPHIC CHARACTERISTICS**

Variables	Experimental group (n=53)		Control group (n=35)		p-Value	Statistics
	M ± SD		M ± SD			
Age (y)	42.3 ± 9.6		40.2 ± 10.6		0.333	a
Height (cm)	161.9 ± 6.0		159.6 ± 6.1		0.075	a
Weight (kg)	60.6 ± 11.9		56.3 ± 8.1		0.066	a
Gender	n	(%)	n	(%)	0.472	b
Male	9	(17.0)	4	(11.4)		
Female	44	(83.0)	31	(88.6)		
Marital status					0.564	b
Yes	18	(34.0)	14	(40.0)		
No	35	(66.0)	21	(60.0)		
Education level					0.317	b
High school	7	(13.2)	3	(8.6)		
College	40	(75.5)	24	(68.6)		
Masters degree	6	(11.3)	8	(22.8)		
Chronic disease					0.437	b
None	45	(84.9)	28	(80.0)		
Diabetes mellitus	2	(3.8)	0	(0.0)		
Hypertension	2	(3.8)	3	(8.6)		
Arthritis	1	(1.9)	0	(0.0)		
Others	3	(5.6)	4	(11.4)		
Time spent sitting					0.119	b
<4 h a day	18	(34.0)	6	(17.1)		
4-6 h a day	11	(20.8)	13	(37.1)		
>6 h a day	24	(45.2)	16	(45.8)		
Exercise habits					0.391	b
None	14	(26.4)	14	(40.0)		
1-2 times a week	22	(41.5)	11	(31.4)		
Irregular	17	(32.1)	10	(28.6)		
Occupation					0.057	b
Gov. employee	34	(64.2)	29	(82.9)		
Businessperson	19	(35.8)	6	(17.1)		

a = Independent sample t-Test; b = Chi-Square Test

Of the remaining 63 cases, 60 completed the pre- and post-test, but only those who attended more than two-thirds of the exercise sessions were included in the data analysis; thus, a final sample of 53 participants were included in the experimental group. Of the 53 original participants in the control group, 18 were unable to participate in the post-test (1 had lower backache, 1 had a cold, 2 were abroad, 10 were on business trips or busy at work, and 4 were unable to participate because of family reasons). Thus, a total of 35 participants completed both the pre- and post-test in the control group.

Thus, 88 participants across both groups completed the pre- and post-test. Descriptive statistics for their demographic characteristics are shown in Table 1. The independent-sample t-test and Pearson's chi-square test found no significant differences between the experimental and control groups for gender, age, height, weight, marital status, education level, chronic disease, time spent sitting, exercise habits and occupation ($p>0.05$ for all parameters).

Changes in body composition

The pre-test body fat percentage ratios were compared for the 2 groups using the independent-sample t-test (Table 2), where no significant differences emerged.

***TABLE 2*: COMPARISON OF PRETEST RESULTS BETWEEN GROUPS FOR BODY FAT PERCENTAGE AND CARDIOPULMONARY FITNESS**

Parameters	**Experimental** (n=53)	**Control** (n=35)	**95% CI**		**t-Score**	**p-Value**
	M ± SD	M ± SD	Low	High		
Body fat %	30.8 ± 6.3	29.6 ± 5.9	-1.46	3.83	0.890	0.376
CPF	61.7 ± 7.9	60.8 ± 10.9	-3.10	4.95	0.458	0.648

CPF = Cardiopulmonary Fitness CI = Confidence Interval

***TABLE 3*: COMPARISON OF PRE- AND POST-TEST BODY FAT PERCENTAGE AND CARDIOPULMONARY FITNESS**

Parameters of groups	**Pre-test**	**Post-test**	**95% CI**		**Paired t-Score**	**p-Value**
	M ± SD	M ± SD	Low	High		
Experimental Gr. (n=53)						
Body fat %	30.8 ± 6.3	30.2 ± 6.0	-0.49	1.70	1.105	0.274
CPF	62.1 ± 7.8	64.9 ± 9.9	-4.97	-0.64	-2.604	0.012*
Control Gr. (n=35)						
Body fat %	29.6 ± 5.9	30.7 ± 6.3	-1.70	-0.42	-3.380	0.002**
CPF	60.8 ± 10.9	58.9 ± 6.9	-1.39	5.12	1.166	0.252

* $p<0.05$ ** $p<0.01$ CPF = Cardiopulmonary Fitness

After the 12-week intervention, the paired t-test was applied to compare the within-group differences between the pre- and post-test results. The body fat percentage ratio of the experimental group decreased from 30.8% (±6.3) to 30.2% (±6.0), but the difference was not statistically significant. However, in the control group, the body fat percentage ratio increased significantly during the study period, from 29.6% (±5.9) to 30.7% (±6.3) (p=0.002), as shown in Table 3.

***TABLE 4*: RESULTS OF ANCOVA FOR POST-TEST RESULTS USING PRETEST AS COVARIATE**

Parameters	Groups	M ± SE	F-Values
Body fat %	Experimental	29.8 ± 0.4	4.535*
	Control	31.3 ± 0.5	
CPF	Experimental	64.6 ± 1.0	10.533**
	Control	59.3 ± 1.3	

* p<0.05 ** p<0.01 CPF = Cardiopulmonary Fitness

Using body fat percentage ratio pre-test of both groups as the covariate, the ANCOVA was conducted to compare the difference of the post-test of both groups. After excluding the effects of the pre-test (Table 4), the F value of the body fat percentage ratio was 4.535 (p=0.036). This result indicates that a significant difference existed between the experimental and control groups for body fat percentage ratio at the post-test. After adjustment, the ratio for the experimental group was 29.8%, which was significantly lower than the control group's ratio of 31.3%.

Changes in cardiopulmonary fitness

The independent-sample t-test served to compare both groups' pre-test values for the cardiopulmonary fitness index. As seen in Table 2, no statistically significant difference was found between the 2 groups. After the 12-week intervention, the paired t-test was conducted to compare the within-group differences between the pre- and post-test. Table 3 shows that the cardiopulmonary fitness index increased from 62.1 (±7.8) to 64.9 (±9.9) in the experimental group, with the difference being significant (p=0.012). In the control group, the cardiopulmonary fitness index decreased from 60.8 (±10.9) to 58.9 (±6.9), but this difference was not significant (Table 3).

Using the cardiopulmonary fitness index pre-test of both groups as the covariate, the ANCOVA was conducted to compare the difference of the post-test of both groups. After excluding the effect of the pre-test (Table 4), the F value of the cardiopulmonary fitness index was 10.533 (p=0.002). This result indicated that the experimental group and control group results differed significantly for the 3-minute step cardiopulmonary fitness index at the post-test. After adjustment, the cardiopulmonary fitness index of the experimental group was 64.6 and that of the control group was 59.3.

DISCUSSION AND LIMITATIONS

Studies on regular exercise interventions with adults are often limited by the need to respect the wishes of participants because it might be unethical to randomly assign participants to different treatment groups in a mandatory fashion. The same problem was encountered in this study. Therefore, the covariance method of statistical analysis was adopted to exclude the differences between the two groups at the pre-test level, thus reducing the potential measurement errors caused by non-random grouping.

For body composition, after the 12-week Pilates intervention, the body fat percentage ratio of the experimental group decreased, whereas it increased in the control group. However, the results showed that Pilates produced no significant effect on body fat percentage ratio in the participants. Previous research has reported ambiguous findings on the effects of Pilates exercise on body composition, with several studies showing that Pilates produced no significant effect on the body fat percentage ratios in adults (Otto *et al.,* 2004; Sekendiz *et al.,* 2007), although another study disagrees (Segal *et al.,* 2004). Another study investigated the effects of a traditional Pilates group mat exercise intervention with 22 adults, implemented three times a week for eight consecutive weeks, and found that Pilates affected body fat percentage ratios significantly (Rogers & Gibson, 2006). A separate study researched 20 sedentary middle-aged women randomised into control (n=10) and experimental (n=10) groups (Arslanoğlu *et al.,* 2011). The experimental group performed three Pilates exercise sessions per week, with each session lasting 45 minutes. Significant decreases were observed in body fat percentage in the women in the Pilates group.

A possible explanation for the lack of positive change in body weight or fat reduction observed in some studies might be that people with a healthy initial weight tend to lose weight more slowly than obese or overweight people (Jakicic *et al.,* 2001). In the present study, no significant difference was found between the experimental and control groups at the pre-test. After the ANCOVA and adjustment, the control group's body fat percentage ratio at the post-test was significantly higher than that of the experimental group. However, the within-group differences for body fat percentage ratio in the experimental group were not significant at pre- and post-test. By contrast, the body fat percentage ratio of the control group had increased significantly at the post-test when compared to the pre-test scores.

These results suggest that the within-group differences in the body fat percentage ratios during the post-test were caused by increased body fat percentage ratios in the control group rather than the decreased body fat percentage ratios in the experimental group. Possible reason for this finding might be that diet has a great effect on body composition, but was not controlled for in the current study because of limited research funding. Moreover, because the study intervention lasted 12 weeks, possible seasonal influences could not be ruled out. Some of the intervention classes were missed during the Chinese New Year period, a time when people generally eat and rest more than normal. This might account for the slight increase in body fat percentage ratios.

After the 12-week intervention, the experimental group showed a significant improvement in cardiopulmonary fitness. Moreover, after adjustment, the post-test cardiopulmonary fitness index was significantly higher in the experimental group than in the control group; this finding indicated that Pilates was helpful in enhancing cardiopulmonary fitness of the adults in this study. Guimarães *et al.* (2011) studied 16 patients with heart failure and randomly assigned them to either a conventional cardiac rehabilitation program (n=8) or mat Pilates training (n=8) for 16 weeks. Both groups increased their exercise tolerance, but only the Pilates group showed a significant increase in ventilation and O_2 pulse. The authors concluded that Pilates involves essentially isometric and respiratory exercises, which may have contributed to the improved respiratory efficiency.

In a separate study, Schroeder *et al.* (2002) conducted Pilates exercise training with equipment three times in one week, with 10 men and women who had not previously experienced Pilates exercise. Their results showed that heart rate did not increase to an appropriate target range through the Pilates intervention. However, the inconsistent results reported by these previous studies might be related to the different cardiopulmonary fitness indices used in various studies. The 3-minute step test, used in this study, is widely accepted as an exercise test for non-maximum perceived exertion. Within a fixed time, people step up and down a ladder rhythmically, and the recovery heart rate is measured at the end of the step test to predict aerobic capacity. A lower heart rate during recovery indicates superior fitness. This test method is more functionally oriented than simply measuring the average or maximum heart rate during exercise.

There were some limitations in the present study. Firstly, the participants' diet was not recorded, thus the effect of diet on the participants' body compositions could not be ruled out. Secondly, individuals with different body compositions may impact the results obtained during the 3-minute step test, and thus may limit the prediction of cardiopulmonary fitness. Thirdly, the intervention was designed according to Polestar Pilates exercise principles, therefore, the results should not be generalised to traditional Pilates exercise. Finally, because group assignment could not be conducted ethically in a mandatory or random fashion, participants were assigned to groups based on their own preferences. Therefore, sampling error associated with non-randomisation could not be eliminated.

PRACTICAL APPLICATIONS

Engagement in regular physical activity is helpful in enhancing physical fitness, which greatly outweighs the potential risks involved (falls and collisions that may cause musculoskeletal injuries). According to this principle, Pilates is a non-contact physical activity because the nature of the exercise involves no physical contact with other people. Thus, the risk of musculoskeletal injuries is low, and Pilates is considered a relatively safe physical activity. One study proposed that Pilates is extremely safe and that even pregnant women can engage in it, with relatively few modifications (Artal & Sherman, 1999). During the current research period, under the instruction of certified supervisors, the participants engaged in Pilates reported no injury. Thus, Pilates is a safe physical activity and is worthwhile to promote health programs.

A recommendation for future research includes continuous tracking for three to six months at the end of the intervention period, to follow-up the intervention effects. This type of longitudinal design can provide a greater understanding of the potential long-term benefits of cardiopulmonary fitness and body composition.

CONCLUSIONS

To date, research has been limited on the effect of Pilates exercise on the body composition and cardiopulmonary fitness of adults. The results showed that, after participants had received 12 weeks of Pilates exercise training, their cardiopulmonary fitness was significantly enhanced, but no statistical difference was found for the body fat percentage ratio. The key findings of this research may serve as a point of reference for people or for follow-up research. Pilates exercise training conducted twice a week for 12 consecutive weeks can promote cardiopulmonary fitness.

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