Experimental Study on Backward Walking Improving Physical Fitness and Balance Capacity in Overweight Females

Xun Sun [a], Jiong Luo, Tingran Zhang, Xiang Wang, Chunli Qin, Jixiang Song, Pingping Yan

College of Physical Education, Southwest University, Chongqing 400715, China

[a]312956993@qq.com

Abstract. The aim of this study was to investigate the effect of backward walking on reducing body fat and improving balance capacity in overweight females. Thirty overweight female college students from Southwestern University voluntarily participated in this study, and were randomly divided into three groups: backward walking group, forward walking group and control group. After 8 weeks of experimental intervention, physical fitness, balance capacity and other relevant indicators were measured by body composition analyzer, balance capacity tester and energy consumption monitor before and after experiment. Compared with those before experiment and of control group, body weight, body fat %, waist girth, calf girth, thigh girth and BMI index obviously decreased in experimental group, while the maximum oxygen uptake, eye-closed single foot support, vertically stepping on wood and frontal split leap significantly increased; in forward walking group, body weight, body fat %, waist girth and thigh girth significantly decreased , maximal oxygen uptake and vertically stepping on wood increased significantly; comparing with six changed indicators both in Group B and Group F, the ability to reduce body weight, body fat and waist girth and improving maximal oxygen uptake was significantly better than that in group F, but no difference was found in other two indicators. Backward walking and forward walking had a significant effect on reducing body fat and improving physical fitness and balance capacity for overweight females, but backward walking had a better fitness effect than forward walking, so it should be recommended to overweight college students or young people.

Keywords: backward walking; physical fitness; balance ability.

1. Introduction

Aerobic exercise is an effective and safe method to lose weight for many obese people. Jogging and walking are the most commonly aerobic exercise to lose weight. For the overweight, knees of the obese always suffer a higher concussion induced by counter-acting force of ground during jogging. The obese who take traditional aerobic exercise always have a higher incidence of knee disease. For the poor balance capacity and coordinate ability, the obese have a higher risk of sprain and falling injury. Backward walking is a new rising aerobic exercise, and an appreciable quantity of people take this kind of aerobic exercise in Japan, Europe and America. Flynn indicated that backward walking could reduce the pressure on knee joint and shin bone, protect anterior cruciate ligament from injury and reduce eccentric loading of knee extensor [1]. In Germany, backward walking is an essential method to recovery knee injury. Radin EL found that backward walking had a smaller vertical counter-acting force of ground compared with forward walking or jogging [2]. Andrews indicated that knee joint had a smaller biological tension during backward walking than that during forward walking [3-4]. Compared with forward walking and jogging, backward walking has a smaller risk of knee injury, and help lose weight and keep knee health. Indicators of backward walking provide an important basis for evaluating falling risk in aged people [5]. Ung RV showed that backward walking could improve the balance capacity and prevent fall injury in children [6]. Zhang Shengnian indicated that backward walking could improve static balance capacity of aged people [7].

Many studies showed that backward walking could improve balance capacity, power and physical fitness. This theory was also applicable to the obese. At the same walk speed, backward walking took more oxygen consumption and higher heart rate than forward walking, that was because backward walking required more energy to conduct metabolism and further to provide stimulation to improve adaption of cardiovascular system [8]. It was shown that backward walking could increase maximum oxygen uptake. [9] Almost all backward walking could induce acute cardiopulmonary reaction after energy consumption. It had been recognized that backward walking took more energy consumption and was good for cardiopulmonary function [10]. There were few studies about the effect of backward walking on reducing body fat and improving balance capacity in China. Just Zhang Shengnian and Zhao Huanbin performed a study about backward walking on improving balance capacity of aged people. With consideration of published literature at home and aboard, we found that backward walking had corresponding mechanism to improving energy consumption and metabolic activity. Recently, there is no study about backward walking on reducing content of body fat and improving balance capacity in overweight females. In this study, we explored the effect of backward walking on reducing content of body fat and improving balance capacity in overweight females, and found that this study provided a scientific basis for the popularization of backward walking in overweight population.

2. Subjects and Methods

2.1. Subjects

Thirty overweight female students were enrolled from Southwest University. All participants had no experience of physical training, backward walking history or organic disease. After obtaining consent of corresponding instructors and these participants, an agreement should be signed. All these 30 volunteers were randomly divided into three groups: backward walking group (Group B), forward walking group (Group F) and no training blank control group (Group C). Each group has 10 participants.

2.2. Methods

Experimental procedures. During the 8-week experiment, the subjects took exercises 5 times each week. The exercises took place at 16:00 to 18:00, and all specified activities should be completed before sunset. Each indicator should be tested every two weeks. Training program was as follows: Group B—backward walking the third track of standard track and field stadium for 12 circles in anti-clockwise direction. Power heart rate meter was used, and targeted heart rate was set at 75 to 100 times/min; Group F—forward walking the third track of standard track and field stadium for 12 circles in anti-clockwise direction. Power heart rate meter was used, and targeted heart rate was set at 75 to 100 times/min; Group C: take normal ordinary life style within these 8 weeks.

Testing of body shape and functional indicators. Indicators of body shape included body weight, content of body fat, thigh girth, calf girth and waist girth; functional indicator was mainly maximum oxygen uptake (as participants were running on running stage, clox cardio-pulmonary function detector was used to conduct graded exercise testing to detect maximum oxygen uptake).

Testing of balance capacity. 1) Balance test of eye closed single foot support: participants began with standing on two feet for an erect position, raised one heel and stood on the forefoot, the other leg lifted with knee compressed, and sole attached to knee medial part of supporting leg. Support time of single foot was measured, and the timing stopped when forefoot of supporting leg moved. The measured value should be accurate to 0.1s. Average value was taken for the results of three tests.

2) Balance test of vertically stepping on wood: after getting the signal, participants should step on wood with single forefoot in line with wood, and the other foot should be off the ground. Support time of single foot was measured, and the timing stopped when forefoot of supporting leg moved. The measured value should be accurate to 0.1s. Each foot should be tested for three times, and total time of these six tests was test results. Average value was taken for results of three tests.

3) Balance test of frontal split leap: participants stood on one foot, jumped towards right to point A, stood on forefoot to maintain balance for 5 seconds, and pushed properly placed wood particles aside by hands with body leaning forward within the first 2 seconds, while heel of supporting foot and the other foot could not touch the ground. Each foot should be tested for two times. Participants can get 5 points if the foot correctly stepped on point A, or small wood particles were pushed aside within 2 seconds after getting balance. Those who maintained balance on point A for 1 second can get a point, and 5 points can be obtained at most. The full mark was 15 points for each test, and 60 points for four tests.

Testing of energy consumption indicator. Energy consumption indicators were tested by American Actigraph GT3X exercise energy consumption monitor (30-100HZ), with 10HZ for an interval. All participants should wear monitor at waist, and take pre-set exercises. GT3X Actigraph software was used to take correlation analysis after test.

Mtatistics method. Descriptive analysis, paired T test, correlation analysis and so on were performed by SPSS for Windows 16.0 in this study. The statistically significant level was set at $\alpha=0.05$ for all indicators.

3. Results

3.1. Repeated measuring results

Each indicator of balance capacity was tested for 3 times for 27 participants being enrolled, and repeat ability test was taken. Correlation coefficient and degree of variation were calculated to make evaluation. The correlation coefficient was more than 0.79, degree of variation within 5%, and significant level was achieved. So each parameter of balance ability had a high reliability.

3.2. Indicators of body shape before and after experiment

Table 1. The index change of body shape, BMI and performance before and after experiment

Index	Backward walking(B)			Forward walking(F)			Control group(C)			LSD test
	Before	After	T	Before	After	T	Before	After	T	
Body mass(kg)	63.12±1.36	59.45±1.28	2.496*	62.89±1.12	60.08±1.16	2.016*	62.91±1.68	63.12±1.65	-0.215	Pbv* Pbc* Pvc*
Percentage of Body fat (%)	34.56±1.34	31.01±1.17	2.551*	34.45±1.61	32.40±1.73	2.359*	33.97±1.95	34.23±1.82	-0.267	Pbv* Pbc* Pvc*
BMI	25.38±1.32	24.27±1.16	2.062*	25.17±0.81	24.61±1.45	1.565	25.13±1.70	25.46±1.34	-0.132	Pbv* Pbc* Pvc
Calf girth(cm)	37.21±1.31	35.15±1.73	3.128*	36.98±1.72	37.10±1.65	-0.223	37.12±0.89	37.33±1.10	-0.214	Pbv* Pbc *Pvc
Thigh girth(cm)	56.49±6.76	52.78±6.03	4.718*	56.92±6.13	54.58±6.45	2.547*	55.98±5.92	56.21±6.11	-0.237	Pbv* Pbc *Pvc*
Waist girth(cm)	88.30±9.66	84.2±9.52	4.082*	87.60±9.95	84.95±9.53	3.651*	86.60±9.61	87.30±9.90	-0.719	Pbv Pbc* Pvc*
VO2max(ml/kg/min)	34.51±7.15	37.82±4.36	4.241*	34.05±5.52	35.69±6.76	2.132*	33.96±4.95	34.04±6.88	0.239	Pbv* Pbc *Pvc*

Note: * indicates significant at $p<0.05$, ** indicates significant at $p<0.01$

1) Before experiment, there was no difference in body weight, Body Mass Index (BMI), content of body fat, thigh girth, calf girth and waist girth among participants in Group B, F and C; 2) After 8 weeks, body weight, body fat % and thigh girth obviously decreased in Group B and Group F compared with those before experiment, but they were lower in Group B compared with group F at the same period; 3) Calf girth and BMI obviously decreased in Group B, but had no obvious change in Group F; 4) After experiment, waist girth obviously decreased in Group B and Group F compared with those before experiment, but no difference was found in waist girth between Group B and Group F; 5) After experiment, there were significant differences in body weight, body fat %, calf girth, thigh girth, waist girth and BMI between Group B and Group F; 6) After experiment, maximum oxygen uptake significantly increased in Group B and Group F compared with that before experiment, but the amount of Group B was significantly higher than that of Group F; 7) No difference was found in control group between that before and after experiment.

3.3. Conditions of balance capacity before and after experiment

Before experiment, there was no difference in balance ability test of eye-closed single foot support, vertically stepping on wood and frontal split leap among participants in Group B, F and C; 2) After 8 weeks, the balance ability indicators of eye closed single foot support, vertically stepping on wood and frontal split leap obviously improved in Group B compared with those before experiment; 3) In Group F, balance ability indicator of vertically stepping on wood obviously improved, but other indicators had no obvious change; 4) No difference was found in control group between that before and after experiment.

Table 2 the test index of balance ability before and after experiment

Backward walking (B)			Forward walking (F)			Control group (C)			LSD test
Before	After	T	Before	After	T	Before	After	T	
9±5	22±4、	11.353**	10±3	14±5	1.762	7±5	9±4	0.871	Pbv** Pbc** Pvc
33±11	71±19	19.661**	36±9	46±11	6.893*	34±16	30±11	-1.856	Pbv**Pbc** Pvc*
24±18	33±15	8.974**	22±9	23±7	0.703	23±11	20±7	-1.236	Pbv**Pbc** Pvc

Note: * indicates significant at $p<0.05$, ** indicates significant at $p<0.01$

4. Analysis and Discussion

4.1. Effect of backward walking and forward walking on female body shape

The 8-week experiment showed that body weight, body fat % and thigh girth obviously decreased in Group B and Group F compared with those before experiment; body weight, body fat % and thigh girth in Group B were obviously lower than those in Group F at the same period. Hopper thought that aerobic exercise at moderate intensity lasting for over 30 minutes or aerobic exercise at low intensity lasting for over 45 minutes could reach the efficacy for reducing body fat [11]. Edward Fox indicated that sugar consumption was more than fat consumption at the former 30 minutes of aerobic exercise. The oxidation energy supply ratio of body sugar and body fat was 50% at the 30st minute during aerobic exercise, when a crossing point was formed. Afterwards, fat energy supply was more than sugar. Heart rate of participants being controlled within 75-100 times/min refers to aerobic exercise at low intensity. It took over 55 minutes for participants in Group B and Group F to walk around standard ground track field for 12 cycles; body weight and body fat obviously decreased for participants in Group B and Group F due to long-time aerobic exercise. Sparto PJ found that with the decrease of human body’s visual perception ability, stress reaction would be produced, and lower limbs muscle would explode in advance. Excitement of muscular activity was higher than that at clear visual perception. Compared with forward walking, visual perception ability decreases during backward walking [12]. Flynn TW proposed that oxygen consumption and heart rate were higher during backward walking than that during forward walking at the same walk speed, which indicated that backward walking had more metabolic activities, and this stimulation could enhance adaption of cardiovascular system. Elmarie thought that there was no significant difference in metabolic rate between backward walking and jogging, but the metabolic rate was obviously higher during backward walking than that during forward walking [14]. In this study, American Actigraph GT3X human exercise energy consumption monitor was used to test relevant indicators of participants in Group B and Group F, and the results showed that average energy consumption was larger in Group B compared with that in Group F, and was about 1.37 times. Body weight and content of body fat obviously decreased, and reducing level of body fat was higher in Group B compared with Group F.

Calf girth obviously decreased for participants in Group B, but there was no obvious change in Group F. Through myoelectricity, Grassoeta found that these two exercise modes had different propulsion sources. The driving force for forward walking was provided by musculus extensor of hip joint and knee joint, while backward walking was driven by plantar flexors of ankle joint [14]. The results of an experiment conducted by Luo Jiong and Zhang Tingran showed that ankle point was the main part to produce driving force and absorb concussion, and knee joint and hip joint almost did not produce driving power for backward walking;, during forward walking, the electric activities of all thigh muscles (except for rectus femoris) are less active than those during backward walking, for the electric activities of biceps femoris muscle, vastus medialis and vastus lateralis are obviously more active than those during backward walking[15]. Compared with forward walking, calf muscle had more movements during forward walking that it was a good exercise to reduce calf girth. Moreover, change of maximum oxygen uptake was more obvious in Group B than that in Group F. Maximum oxygen uptake is an important indicator to evaluate aerobic exercise ability, and can reflect cardiac mechanism, cardiovascular mechanism, peripheral mechanism, pulmonary ventilation, gas exchange and cellular oxygen utilization coefficient. It is affected by various factors, and its level is determined by oxygen transportation system, heart pump function, and oxygen utilization by muscular tissues.

Some studies showed that maximum oxygen uptake would increase after a period of exercise training, because the cardiac central adaption was improved, ie SV increased. Flynn thought that backward walking could increase maximum oxygen uptake by 28% compared with forward walking. Chaloupka found that backward walking could improve maximum oxygen uptake and stroke volume. Hreljac found that backward walking could improve metabolism, pulmonary permeability and maximum oxygen uptake. Edward indicated that backward walking could improve maximum oxygen uptake by 24±7.8% compared with forward walking

In this research, body weight, body fat %, thigh girth and waist girth gradually decreased at different degrees and maximum oxygen uptake increased for participants taking backward walking in Group B and forward walking in Group F. However, the comparison between two groups showed that most detecting indicators had obvious changes in Group B, and calf girth obviously decreased for participants in Group B, and this phenomenon was not found in Group F.

4.2. Effect of backward walking and forward walking on balance capacity

The 8-week experimental results showed that balance capacity of eye closed single foot support, vertically stepping on wood and frontal split leap obviously improved in Group B compared with that before experiment; Schneider indicated that backward walking each day could improve adaptation of soleus muscle to H-reflex; Van Deursen et al indicated that both forward walking and backward walking are coordinated by the same central pattern generator, different features of these two modes are induced by mild modification of CPG[16]. During backward walking, coordination of lower limb muscles and control of nerve actions can improve and acquire balance capacity. The results of an experiment conducted by Brugge et al showed that backward walking was good for children, could enhance balance capacity and avoid falling injury [17]. Zhang Shengnian found that backward walking could obviously improve static balance capacity of aged people. Compared with normal weight people, balance capacity of overweight people is poor for overweight, excessive body fat and low muscular content, so overweight people have a higher possibility of falling injury than normal weight people [18]. It is necessary for overweight people to take exercise for improving balance capacity. After experiment, the balance capacity of single foot support and vertically stepping on wood obviously improved in Group B, which showed that backward walking could obviously improve static balance capacity; the obvious increase of balance capacity of frontal split leap indicated that backward writing could enhance dynamic balance capacity. Backward walking can improve balance capacity, and is appropriate for the obese. In Group F, balance indicator of vertically stepping on wood obviously enhanced, and other indicators had no obvious change. The results showed that forward walking could improve static balance capacity, but its effect on dynamic balance capacity is not obvious. Li Jing et al found that forward walking could improve static balance capacity, but its effect on dynamic balance capacity is unclear. Wikstrom though that the reasons for forward walking to improve static balance capacity is weight loss and higher control on muscle.

5. Conclusion

1) Backward walking and forward walking are effective weight loss methods to reduce body weight, body fat %, thigh girth and waist girth of overweight females. Under the conditions of same exercise intensity, backward walking has a better weight loss effect than forward walking, especially to reduce calf girth.

2) Both backward walking and forward walking can enhance maximum oxygen uptake, but the former is better than the latter.

3) Backward walking can improve static and dynamic balance capacity. Forward walking can only enhance static balance capacity.

References

[1] Flynn T W, Connery S M, Smutok M A, Zeballos R J,Weisman I M 1994 Comparison of cardiopulmonary responses to forward and backward walking and running[J]. Medicine and Science in Sports and Exercise,1994(26):89-94.

[2] Radin EL, Yang KH, Riegger C, Kish VL, O'Connor JJ. Relationship between lower limb dynamics and knee joint pain[J]. J Orthop Res, 1991(9):399-405.

[3] Andrews M, Noyes FR, Hewett TE, Andriacchi TP. Lower limb alignment and foot angle are related to stance phase knee adduction in normal subjects: a critical analysis of the reliability of gait analysis data[J]. J Orthop Res,1996(14):289-295.

[4] Subotnick ST. Podiatric Sports Medicine. Mount Kisco, NY: Futura Publishing. 1975.

[5] Flynn T W, Soutas-Little R W Mechanical power andmuscle action during forward and backward running[J].Journal of Orthopaedic & Sports Physical Therapy ,1993(17):108-112.

[6] Ung RV, Imbeault MA, Ethier C, Brizzi L, Capaday C. On the potential role of the corticospinal tract in the control and progressive adaptation of the soleus H-reflex during backward walking[J]. Journal of Neurophysiology,2005(94):1133–1142.

[7] ZHAO Huanbin, HUO Hongfeng,ZHANG Jing, et al. Foot pressure and gait features during fitness backward walking of the elders [J]. Chinese Journal of Rehabilitation, 2010, 25(5): 436-438.

[8] Flynn T W, Soutas-Little R W Patellofemoral joint compressive forces in forward and backward running[J].Journal of Orthopaedic & Sports Physical Therapy,1995(21):277-282.

[9] Flynn T W, Connery S M, Smutok M A, Zeballos R J,Weisman I M Comparison of cardiopulmonary responses to forward and backward walking and running[J]. Medicine and Science in Sports and Exercise,1994(26):89-94.

[10] Myatt M, Baxter R, Dougherty R et al. The cardiopulmonary cost of backward walking at selected speeds[J].Journal of Orthopaedic & Sports Physical Therapy ,1995(21): 132-138

[11] Hooper TL, Dunn DM, Props JE, Bruce BA, Sawyer SF, Daniel JA. The effects of graded forward and backward walking on heart rate and oxygen consumption[J]. Journal of Orthopaedic & Sports Physical Therapy,2004(34):65–71.

[12] Sparto PJ, Redfern MS, Jasko JG, Casselbrant ML, Mandel EM, Furman JM. The influence of dynamic visual cues for postural control in children aged 7-12 years[J]. Exp Brain Res., 2006 (168): 505–516.

[13] Underwood FB The effect of repeated bouts of backward walking on physiologic efficiency[J]. J Strength Cond Res, 2002(16): 451–455.

[14] R. Grasso, L. Bianchi, F. Lacquaniti Motor patterns for human gait: backward versus forward locomotion[J]. Journal of Neurophysiology, 1998(80) p: 1868–1885

[15] Schneider C, Capaday C. Progressive adaptation of the soleus H-reflex with daily training at walking backward[J]. Journal of Neurophysiology,2003(89): 648-656.

[16] van Deursen RW, Flynn TW, McCrory JL, Morag E. Does a single control mechanism exist for both forward and backward walking [J]. Gait & Posture, 1998(7): 214-224.

[17] Zhang Shengnian , Lin Zhongbao, Yuan Yonghong , Wu Xinfan. Effect of Backward-Walking on the Static Balance Ability and Gait of the Aged People [J]. Chinese Journal of Sports Medicine,2008,27(3):304-307.

[18] Wikstrom EA, Tillman MD, Smith AN, Borsa PA. A New Force-Plate Technology Measure of Dynamic Postural Stability: The Dynamic Postural Stability Index[J].Journal of Athletic Training, 2005(40):305–309.