ORIGINAL RESEARCH

Exercise Intervention Based on Behavioral Change Theory: Influence on Body Morphology and Body Composition

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ABSTRACT

Context • Increased sedentary time and insufficient physical activity have become independent risk factors for chronic diseases. An exercise intervention can focus on increasing an individual's amount of exercise to change his or her body shape and body composition. No studies have occurred to find out if any relationships exist between the amount of exercise and body shape and body composition.
Objective • The research team intended to determine an effective way of improving an individual's body shape and composition and to analyze the relationship between moderate-to-vigorous physical activity (MVPA) and body shape and composition.
Design • This study used the method of Pre- and post-control experiments.
Setting • The study took place at the Science Island Health Promotion Demonstration and Application Center in Hefei, People's Republic of China.
Participants • Participants were 62 community residents at the center, aged 20-60 years. Of them, 46 completed the study, and their data were analyzed.
Intervention • The exercise prescriptions were based on each participants' stage, as defined by the Transtheoretical Model of Behavior Change (TTM) theory: pre-intention, intention, preparation, action, or maintenance. The exercises were recommended according to each participant's physical condition, with targeted exercise-technique instructions and methods of prevention of exercise injuries being given for each exercise prescription.
Outcome Measures • At baseline and post-intervention, the research team measured body weight, waist-to-hip ratio, abdominal-fat weight, body mass index (BMI), body-fat weight, body-fat percentage, muscle weight, and muscle percentage.
Results • Significant reductions in participants' body weights and abdominal-fat weights occurred between baseline and postintervention, with $P = .00$ and $P < .01$, respectively, and while their waist-to-hip ratios decreased, the difference wasn't significant. Participants' body compositions significantly improved between baseline and postintervention, with $P \leq .01$ for all indices. A positive correlation existed between BMI and body weight and between BMI and abdominal-fat weight, both at baseline and post-intervention, with $P < .01$ for all correlations, but no correlation existed between BMI and the waist-hip ratio at either time. At baseline, a positive correlation existed between body-fat weight and body weight ($P < .01$), but no correlation existed between body-fat percentage and body weight at that time. At baseline, a significant correlation was found between skeletal-muscle weight and body weight and between skeletal-muscle weight and waist-hip ratio with $P < .01$ for all correlations. No correlation existed between skeletal-muscle weight and abdominal-fat weight at baseline, but a positive correlation was found between skeletal-muscle weight and abdominal-fat weight post-intervention ($P < .05$). Both at baseline and postintervention, the muscle percentage was negatively correlated with the waist-to-hip ratio and abdominal-fat weight, with $P < .01$ for all correlations, and no correlation existed between muscle percentage and body weight at either time.
Conclusions • The eight-week intervention significantly improved participants' body morphology and had corresponding effects on their body composition. A positive correlation existed between participants' body fat and body shape, and an opposite relationship was found between skeletal muscle and body shape, which could be increased using the intervention. Body fat was the core factor that affected participants' body morphology. (*Altern Ther Health Med.* 2023;29(1):150-155).

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With the rapid development of the Chinese economy, the work activities and lifestyles of residents have undergone great changes. Increased sedentary time and insufficient physical activity have become independent risk factors for chronic diseases, and these factors also provide the most difficult public-health problem to be solved worldwide at present.

Body Shape

The indices that researchers use to evaluate body shape are body weight, waist-to-hip ratio, and weight of abdominal fat. Body weight is made up of fat-free weight and fat weight.[1]

High amounts of adipose tissue in the midsection can increase the risk of inflammation and associated diseases,[2] which is the main reason to discuss body shape when the focus is on health and disease prevention. One study has shown that abdominal-fat accumulation is related to a variety of diseases and that reducing the abdominal-fat mass can effectively reduce health risks.[3]

The measurement of the waist-to-hip ratio is simple and convenient and can determine the fat parameters in the abdominal cavity. One study has shown that the waist-to-hip ratio is related to the fat content in the abdominal cavity Waist-to-hip ratio was used to determine obesity by the ratio of waist circumference to hip circumference, a high waist-to-hip ratio indicates a higher accumulation of abdominal fat.[4] What waistline reflects is an abdominal cavity and abdomen subcutaneous deep layer adipose thickness degree and abdominal muscle volume size, used at reflecting abdomen adipose accumulation degree commonly. Hip circumference is another important index of body morphology, what reflects is the development circumstance of pith ministry skeleton and muscle, auxiliary waist circumference can evaluate metabolism Syndrome, hip itself is not easy to hoard fat like waist abdomen, the fat layer around the hip is relatively thin. The proportion of fat that can be used in the exercise is relatively small, and the high waist-to-hip ratio indicates more abdominal fat accumulation. Therefore, the waist-to-hip ratio also reflects the attachment of abdominal fat to and the amount of visceral fat. [5]

Controlling the waist-to-hip ratio is an effective way of preventing obesity.[6] That ratio is a key indicator in evaluating obesity because it reflects the distribution of fat in the abdomen and buttocks. The accumulation of fat in those locations can cause obesity, with the fat adhering to the abdominal organs.[7]The waist-to-hip ratio is more accurate in determining obesity than is the body mass index (BMI).[8]

Body-fat weight can be an important index affecting body shape, and Alizadeh et al found that people's body shapes change with an increase in fat content.[9] Biadgilign et al[10] have pointed out that body shape can be effectively improved with a reduction in the body-fat weight, and those researchers found a positive correlation between body-fat weight and the waist-to-hip ratio, body weight, abdominal fat, and other indicators. At the same time, they found a negative correlation between skeletal muscle and body shape, and a positive correlation between skeletal muscle and body weight, waist-to-hip ratio, and abdominal fat.

Some studies have focused on body-shape control from the perspective of preventive medicine, using such methods as exercise interventions, nutritional interventions, and surgery.[11] The daily caloric consumption of the human body is determined by the total metabolic value of the human body, adherence to regular exercise, improvement of the energy consumption of the body, improve activity metabolism, improve the amount of cell activity, to improve the effect on body shape. Regular and moderate exercise can improve a person's metabolic basis, consume energy, and reduce the volume of fat cells.[12] The increase of adipose tissue is the basic characteristic of obesity, which is mainly the increase of the volume and/or many adipose cells at the cellular level. Individuals who strictly implement exercise prescriptions can increase physical activity and improve body-cell vitality, burn fat, and reduce weight.[13] The increase in physical activity can consume calories, effectively control the growth of the fat area, provide favorable conditions for weight loss and fat reduction, and achieve the effect of weight loss.
Some studies have found that intermittent exercise interventions and health education can reduce the body weight of participants.[14,15]

Body Composition

The indices that researchers use to evaluate body composition are BMI, body-fat weight, body-fat percentage, skeletal muscle weight, and muscle percentage. Body composition directly reflects the distribution of water, inorganic salts, body fat, and muscle in the body and is a key factor for health. An abnormal distribution of body components can increase the risk of chronic diseases, such as obesity, hypertension, and diabetes.[16]

As an energy load, body fat can stimulate skeletal muscle and promote the metabolism of skeletal muscle. [17] Reducing body fat can improve body shape.[18] Li G et al[18] found that increases in the skeletal-muscle indices could have a significant effect on body shape. The fat component in muscle will cause friction when the muscle contracts, which reduces the mechanical efficiency of the muscle when doing work. Adhering to the exercise prescription recommended by the experiment can increase the amount of physical activity, which reduces the fat component in skeletal muscle and improves contraction efficiency.

The European Association for the Study of the Liver (EASL), European Association for the Study of Diabetes (EASD), and European Association for the Study of Obesity (EASO) have formulated the EASL-EASD-EASO Clinical Practice Guidelines for the Management of Nonalcoholic Fatty Liver Disease.[19] Their guidelines indicate that a significant reduction in body fat can be found through an exercise intervention. Later studies also showed that exercise interventions can effectively improve body fat rates.[1]

Exercise Interventions

Available studies have shown that individuals' lifestyles directly affect their physical health, with inadequate moderate-to-vigorous physical activity (MVPA) and an imbalanced body shape being highly associated with cardiovascular-disease risk.[20] Miller et al found that eight weeks of an exercise intervention can increase the amount of exercise and reduce weight, and more than 10% of individuals showed a significant decrease in lipids.[21]

Behavioral change theory includes social cognition theory, cross-theoretical model, etc., which is a general concept. Some studies have shown that sports interventions based on that theory can have a significant impact on an individual's body shape.[22] Other studies have shown that an intervention based on behavioral change theory can reduce the body-fat weight of individuals and can effectively improve body-fat distribution.[23] This type of exercise intervention is highly targeted and prescribes exercise prescriptions based on individual's physical condition.

In1983, Prochaska and DiClemente[22,23] developed the Transtheoretical Model of Behavior Change (TTM), which has been widely for health interventions. Based on the staged interventions of behavioral change theory, the TTM theory divides individuals into exercise-habit cultivation groups: (1) in the pre-intention stage, an individual will take no action in the next 180 days; (2) in the intention stage, an individual will consider taking action in the next 180 days; (3) in the preparation stage, an individual will prepare to take action within 30 days; (4) in the action phase, an individual will have changed his or her behavior for 180 days; and (5) in the maintenance phase, an individual will have changed his or her behavior for more than 180 days. In scientific studies, researchers can use those groups to create defined fitness groups and focus on intervention measures that can effectively increase movement, improve participants' exercise adherence, and improve the external forms and characteristics of their bodies.

Other studies have shown that an exercise intervention based on behavioral change theory can not only increase the amount of time an individual spends exercising but also produce a dose-effect. [15,24-27]Based on the distribution characteristics of individual stages of change, individualized exercise intervention programs are proposed in stages to improve the self-efficacy of participating in exercise, make the decision-making balance develop in a positive direction, so that the process of change can be developed in an upward stage or several stages. The relationship between an individual's MVPA and his or her body morphology and body composition is complex, and heterogeneity exists among the existing research results.

An exercise intervention can focus on increasing an individual's amount of exercise to change his or her body shape and body composition. No studies have occurred to find out if any relationships exist between amount of exercise and body shape and body composition. The World Health Organization (WHO) recommends a daily amount of MVPA for adults, but many Chinese residents don't meet the requirements.[28]

Therefore, the current study intended to determine an effective way of improving an individual's body shape and composition and to analyze the relationship between MVPA and body shape and composition.

METHODS

Participants

Some public hospitals in China use the Sports Health Promotion Intervention Department developed by the Hefei Institute of Materials Research at the Chinese Academy of Sciences in Hefei, People's Republic of China, to conduct health check-ups for members of communities. The study took place at the Science Island Health Promotion Demonstration and Application Center in Hefei, where the research team recruited community residents for the study. A health examination and questionnaire were administered to the participants before the experiment, and their contact information was registered.

Potential participants were included in the study if they were aged between 20 and 60.

Potential participants were excluded from the study if they: (1) showed symptoms of cardiovascular or cerebrovascular disease, health examination, and questionnaire interview were conducted before the experiment; (2) had been diagnosed with cardiovascular or cerebrovascular diseases or lung or kidney diseases or had related complications; (3) had severe diabetes or related complications; (4) had a fasting blood glucose of ≥13.3 mmol/L+ positive urinary ketone or postprandial blood glucose ≥19.4 mmol/L, or (5) had a resting blood pressure of ≥160/100 mmHg; (5) had exercise taboos, such as high blood pressure prevents strenuous exercise; or (6) were cognitively dysfunctional.

According to the Helsinki Declaration, the study was approved by the Ethics Committee of the Hefei Institute of Physical Science at the Chinese Academy of Sciences in Hefei. The purpose of the study was explained to all participants and an informed consent form was signed.

Procedures

Intervention. The Sports Health Promotion Intervention Department assessed each individual's physical condition and lifestyle based on the different stages of the TTM theory and recommended exercise prescriptions after the testing has occurred.

Participants completed the TTM self-assessment questionnaire, which was used to divide participants into two groups: (1) the exercise-habit-formation group, which included participants in the pre-intention, intention, and preparation stages, and (2) the scientific fitness group, which included participants in the action and maintenance stages. For the exercise-habit-formation group, the main goal was the cultivation of exercise habits.

Outcome measures. The main data collected included measurement of body weight, waist-to-hip ratio, abdominal-fat weight, body mass index (BMI), body-fat weight, body-fat percentage, muscle weight, and muscle percentage.

Figure 1. Process of Sports Health Promotion Intervention Department

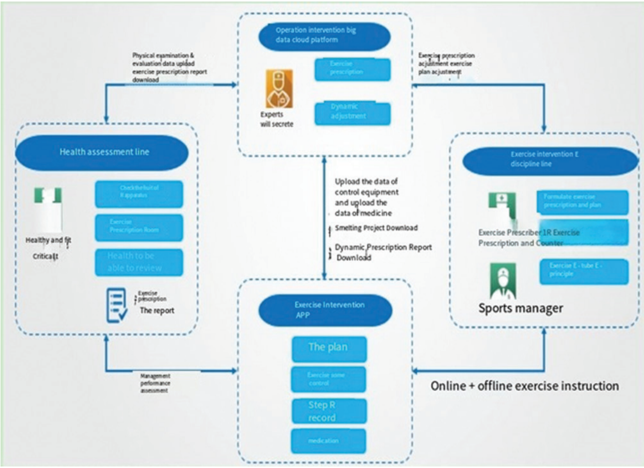

Figure 1 shows the process of the Sports Health Promotion Intervention Department when evaluating an individual's physical condition and lifestyle based on the different stages of the TTM theory and recommending exercise prescriptions.

The Sports Health Promotion Intervention Department assessed participants' body shapes and compositions at baseline and post-intervention. The Sports Health Promotion Intervention Department performs testing using: (1) a cardiovascular function tester, model BX-CFTI from manufacturer Hefei Zhongke Boxie Technology Co., LTD (Hefei, Anhui, China); (2) an atherosclerosis tester, model BX-CFTI-100 from manufacturer Hefei Zhongke Boxie Technology Co., LTD (Hefei, Anhui, China); (3) an ultrasonic bone density tester, model BX-BDI-500A from manufacturer Hefei Zhongke Boxie Technology Co., LTD (Hefei, Anhui, China); and (4) a body composition analyzer, model BX-BCA-100 from manufacturer Hefei Zhongke Boxie Technology Co., LTD (Hefei, Anhui, China).

The department also performed an assessment of risk factors for chronic diseases, such as behavioral patterns, dietary habits, genetics, emotions, and other basic physiological indicators through interviews and questionnaires.

Intervention

For the exercise-habit-formation group, each participant's evaluation provided a plan that included: (1) targeted health education through the distribution of sports- and health-education manuals; (2) provision of fitness knowledge. At 8 o 'clock every night, we will provide advice on fitness techniques and movements in the form of video conversations; (3) targeted interviews for participants showing low compliance with the intervention to improve their enthusiasm for participating in sports; (4) assessments: Questionnaire evaluation was carried out after health examination, mainly for medical history, lifestyle, eating habits, etc. to recommend sports, such as walking, brisk walking, or jogging; (5) provision of online or on-site technical sports guidance, including information for the prevention of sports injury; (6) registration for *Clock in Motion* in the WeChat group, to record motion-time steps, projects, intensity, and movement; and (7) recommendations for exercising more than two times per week, with every time being not less than 10 min. The intensity of exercise wasn't set.

For the scientific fitness group, the goal was to maintain exercise habits. Each participant's evaluation provided a plan that included: (1) promotion of exercise intensity to a high level; (2) combined aerobic and resistance exercise; (3) adoption of the procedures provided by online or on-site guidance; (4) use of correct movement technology, Professional instruction in exercise techniques was provided through video and offline instruction, as some participants may experience incorrect movements during exercise, resulting in injuries; (5) involvement in a sports injury prevention intervention, The correct exercise technique was provided by a professional; (6) targeted interviews for participants showing low compliance with the intervention to improve their enthusiasm for participating in sports; (7) registration for *Clock in Motion* in the WeChat group, to record motion-time steps, project, intensity, and movement, and (8) recommendations for exercising more than 3 times a week for 30-60 minutes each time.

In addition, participants' daily steps, exercise items, and exercise time were recorded during the intervention. The amount of physical activity of participants was recorded by the researcher by sensing the number of steps.

Outcome Measures

Body weight, waist-to-hip ratio, abdominal-fat weight, body mass index (BMI), body-fat weight, body-fat percentage, muscle weight, and muscle percentage was obtained by holding the handle while the participant stood barefoot on the body composition analyzer.

Statistical Analysis

SPSS 18.0 software (IBM Corporation, Armonk, New York, USA) was used to establish a database for analysis. Experimental data were presented using means ± standard deviations (SDs). A paired sample t-test was used for body shape and -composition data at baseline and post-intervention, and Pearson was used for the correlation analysis of body shape and composition.

RESULTS

Of the 62 original participants, 16 participants dropped out during the study, and 46 participants strictly implemented the exercise prescription and were included in the analysis. Their mean age was 44.37 ± 12.18 (data not shown).

Body Shape

Table 1 shows significant reductions in participants' body weights and abdominal-fat weight between baseline and postintervention, with $P = .00$ and $P < .01$, respectively, and while their waist-to-hip ratios decreased, the difference wasn't significant.

Body Composition

Table 2 shows significant changes in participants' body compositions between baseline and post-intervention. Participants' BMIs ($P = .00$), body-fat weight ($P = .00$), and body fat percentage ($P = .00$) were significantly reduced, and their skeletal-muscle weight ($P = .01$) and muscle percentage ($P = .00$) were significantly increased.

Correlation of Body Morphology and Composition

Table 3 shows a positive correlation between BMI and body weight and between BMI and abdominal-fat weight, both at baseline and post-intervention, with $P < .01$ for all correlations, while no correlation existed between BMI and the waist-to-hip ratio at either time. However, that index had increased by 0.11 between baseline and post-intervention.

A significant positive correlation existed between body-fat weight and body weight and between body-fat weight and abdominal-fat weight, both at baseline and post-intervention with $P < .01$ for all correlations. Body-fat weight was positively correlated with all body-shape indices at baseline and post-intervention, with $P < .05$ for its correlation with the waist-to-hip ratio at baseline, and $P < .01$ for all other correlations at baseline and post-intervention.

Both at baseline and post-intervention, the body-fat percentage was significantly correlated with waist-to-hip ratio and abdominal-fat weight, with $P < .01$ for all correlations, but no correlation existed between body-fat percentage and body weight at either time.

Both at baseline and postintervention, a significant positive correlation was found between skeletal-muscle weight and body weight and a significant negative correlation between skeletal-muscle weight and waist-to-hip ratio, with $P < .01$ for all correlations, but no correlation existed between skeletal-muscle weight and abdominal-fat weight at baseline. A positive correlation was found post-intervention between skeletal-muscle weight and abdominal-fat weight ($P < .05$). Both at baseline and postintervention, the muscle percentage was negatively correlated with waist-to-hip ratio and abdominal-fat weight, with $P < .01$ for all correlations, but no correlation was found between muscle percentage and body weight at either time.

DISCUSSION

Body Shape

No significant difference in the waist-to-hip ratio was found in the current study after the eight-week intervention based on behavioral change theory, but the mean value decreased between baseline and post-intervention. This may be due to the large areas of the waist and buttocks fat, the relatively concentrated fat, and the short intervention time, resulting in the lack of significance.

The current study showed that the abdominal-fat weight was positively correlated with BMI, body-fat weight, body-fat percentage, and muscle percentage, and it's often used to describe abdominal, visceral fat weight. The current study showed that an intervention based on behavioral change theory could reduce abdominal fat.

Table 1. Changes in Participants' Body Shapes Between Baseline and Postintervention After an Intervention Using Behavioral Change Theory (N = 46)

Indicators	Baseline Mean ± SD	Postintervention Mean ± SD	*t*	*P* Value
Body weight, kg	67.88 ± 13.41	65.96 ± 12.97	7.56	.00[a]
Waist-to-hip ratio	0.77 ± 0.08	0.76 ± 0.08	1.3	.20
Abdominal fat, kg	8.59 ± 3.33	7.8 ± 3.17	3.71	.001[a]

[a]Shows significant reductions between baseline and postintervention

Abbreviations: BMI, body mass index.

Table 2. Changes in Participants' Body Compositions Between Baseline and Postintervention After an Intervention Using Behavioral Change Theory (N = 46)

Indicators	Baseline Mean ± SD	Postintervention Mean ± SD	*t*	*P* Value
BMI	23.99 ± 3.17	23.36 ± 3.03	7.52	.00[a]
Body fat, kg	16.2 ± 5.5	15 ± 5.07	4.53	.00[a]
Body fat rate, %	23.88 ± 6.74	22.69 ± 6.51	3.54	.00[a]
Skeletal muscle, kg	48.85 ± 10.51	48.33 ± 10.05	2.56	.01[a]
Muscle rate, %	72.11 ± 6.57	73.26 ± 6.36	-3.54	.00[a]

[a]Shows significant changes between baseline and postintervention

Abbreviations: BMI, body mass index.

Table 3. Correlations Between Participants' Body Shapes and Body Compositions at Baseline and Postintervention After an Intervention Using Behavioral Change Theory (N = 46)

	Baseline			Postintervention		
Indicators	Body Weight kg	Waist-to-hip Ratio	Abdominal Fat kg	Body Weight kg	Waist-to-hip Ratio	Abdominal Fat kg
BMI	0.89[a]	-0.18	0.79[a]	0.89[a]	-0.07	0.77[a]
Body fat, kg	0.62[a]	0.35[b]	0.99[a]	0.62[a]	0.41[a]	0.98[a]
Body fat rate, %	0.02	0.8[a]	0.76[a]	0.04	0.8[a]	0.75[a]
Skeletal muscle, kg	0.92[a]	-0.75[a]	0.29	0.92[a]	-0.64[a]	0.32[b]
Rate of muscle, %	-0.00	-0.81[a]	-0.74[a]	-0.02	-0.81[a]	-0.74[a]

[b]$P < .05$, showing significant correlations between the variables
[a]$P < .01$, showing significant correlations between the variables

Abbreviations: BMI, body mass index.

The relevant indicators of body shape in the current study support the findings of previous research.[29] Therefore, behavior change theory combined with the efforts of the Sports Health Promotion Intervention Department and its intervention methods for community residents was able to effectively control their body shape.

Body Composition

In the current study, body composition, BMI, body-fat weight, and body-fat percentage all decreased between baseline and postintervention, while skeletal-muscle weight and muscle percentage increased. After post-intervention, the changes in all indices of body composition were very significant ($P \leq .01$). The results of the current study are consistent with those of Andreacci et al.[1]

The current study's intervention had a significant effect on and played an important role in improving participants' body compositions. Before the current study, the interventions used to change community residents' body compositions were mainly exercise, diet, and health education, representing a single exercise intervention only. Exercise interventions based on behavior change theory are more scientifically based and comprehensive than a single exercise intervention. The single exercise intervention did not carry out targeted grouping and did not recommend exercise programs according to the physical condition of the subjects.

As global obesity continues to increase and the WHO promotes obesity interventions, expanding research on methods of changing the body compositions of community residents is important and provided theoretical support for methods of chronic disease prevention and treatment.

Correlation of Body Shape and Composition

In the current study, no correlation was found between BMI and the waist-to-hip ratio at baseline or postintervention, but the index was elevated postintervention; therefore, BMI can have a direct impact on body-shape development. An exercise intervention based on behavioral change theory can help community residents to reduce fat and enhance muscle shape, promoting the increase and thickening of muscle fibers.

Summary

An exercise intervention based on behavioral change theory can be of outstanding practical value in forming exercise habits, improving physique, reducing fat, and increasing muscle. In China, community residents can achieve lifestyle interventions on their own through community health cabins, which are free self-examination services provided by the community for residents, and national physical fitness monitoring stations, which are free testing services provided by the government for residents to keep their body composition indices in the normal range, and appropriately increase the amount of exercise to prevent chronic diseases caused by obesity.

CONCLUSIONS

The eight-week intervention significantly improved participants' body morphology and had corresponding effects on their body composition. A positive correlation existed between participants' body fat and body shape, and an opposite relationship was found between skeletal muscle and body shape, which could be increased using the intervention. Body fat was the core factor that affected participants' body morphology.

AUTHORS DISCLOSURE STATEMENT

Zuchang Ma designed the study; Youliang Wu conducted the experiments, analyzed the data and drafted the paper; and all authors approved the paper.

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