The effects of pilates exercise on lipid metabolism and inflammatory cytokines mRNA expression in female undergraduates

Hyo-Jin Kim, Jiyeon Kim and Chang-Sun Kim

Department of Physical Education, Dongduk Women's University, Seoul, Korea

(Received: 2014/07/28, Revised: 2014/09/11, Published online: 2014/09/17)

INTRODUCTION

Pilates is known to strengthen and stabilize the core part of the body by slow and strong muscular contraction repetition with deep breathing. It also enhances the muscles by making the body flexible [36] and balanced while correcting posture [12,16,38]. In addition, Pilates exercise promotes health and beauty [14] and has received particularly high interest among young women [35].

A recent study showed that Pilates exercise enhanced the back muscles for spine stabilization and provided significant benefits in enhancing body flexibility [17]. Another study on pre-menopausal career women reported that the exercise positively improved their bone densities [28] and a musculoskeletal system study reported that Pilates exercise was an effective training program for ballet dancers with spinal deformation to improve pelvis and spine correction efforts [20]. In addition, a psychological study reported that Pilates exercise boosted physical self-efficacy and concept and positively affected emotion [1,19]. In addition, there has been a substantial number of studies on the effect of Pilates exercise on body composition, blood lipid and muscular strength [5, 29,30,34]. However, it is judged that the results of these studies are insufficient to normalize the changes in body composition, blood lipid and muscular strength from Pilates exercise and additional in-depth research is required.

Creatine kinase (CK) is the enzyme which transforms adenosine di-phosphate (ADP) and creatine phosphate into adenosine tri-phosphate (ATP) and creatine. CK exists in large quantities in the muscle [7]. Generally, the substance
fluctuates significantly with exercise, is highly correlated with exercise intensity, time and amount and is used as the biochemical indicator of muscular damage [3]. The type of Pilates exercise performed in the study was resistant Pilates using resistant elastic bands and foam rollers. The study investigated the impact of the exercise on muscular damage by measuring fluctuation of the CK index.

In addition, it is known that regular exercise improves blood lipid levels and decreases arteriosclerosis [2]. It has been reported that long-term exercise decreases TG, TC and LDL levels and increases the level of HDL [39]. A combination of muscular and aerobic exercise has been reported to significantly decrease the level of TG [24]. However, the number of studies on the impact of Pilates exercise on blood lipid metabolism including the levels of TG, TC, LDL and HDL are currently insufficient.

It is known that the TNF-α secreted from mastocytes stimulates the secretion of IL-6 and acute reactive protein, causing athermanous arteriosclerosis in the coronary artery [11]. Positive changes in blood lipid through regular physical activities improve the vascular inflammation indicator implicated as a major factor in vascular disease [15]. A recent study [8] reported that IL-6 and TNF-α significantly decreased as a result of judo practice in obese adolescents. Meanwhile, there were prior reports stating that TNF-α concentration did not significantly change despite continuous aerobic exercise [14,42]. Some studies have also reported that exercise did not cause positive changes in the level of IL-6 [31,42]. There are a lot of research results with opposite conclusions and there has been no studies yet comparing the inflammatory cytokine mRNA concentration after Pilates exercise.

Therefore, this study employed 8 weeks of Pilates exercise for female undergraduates in their 20s to evaluate how the exercise affected lipid metabolism, as well as CK and inflammatory cytokine mRNA changes.

**METHODS**

**Research subject**

The subjects in the study were healthy female undergraduates with no specific diseases and no experience in systematic exercise for the previous 6 months. A total of 22 subjects were recruited for the study, with the Pilates exercise group and the control group containing 11 subjects each. The total number of subjects included in the final analysis was 18, excluding 4 subjects with poor attendance or dropout. The characteristics of the subjects are in Table 1.

**Research procedure**

The research team provided specific information on the purpose and overall process of the study to the subjects and all the participants read the documentation on the study, approved their participation and provided written consent. The study team provided Pilates exercise classes and mats for 8 weeks, then compared and analyzed the physical composition, serum lipid and inflammatory cytokine mRNA expression of the subjects.

**Pilates exercise program**

The Pilates exercise group participated in the exercise program for 70-80 minutes a day, 3 days a week for a period of 8 weeks while the control group enjoyed their everyday lives. The Pilates exercise group was also advised to consume proper nutrition during the exercise period. <Table 2> shows the exercise program. The exercise group performed warm-up with light breathing and stretching for 10 minutes, main exercise for 50-60 minutes and warm down for 10 minutes, for a total of 70-80 minutes. The Pilates exercise program was based on official programs used by the New York Pilates Academy International-Pilates method (PAI) and San Francisco Balanced Body University-Pilates method (BBU) and items were used for the exercise. The exercise intensity was as follows: 1-2 weeks (RPE: 9-12), 3-6 weeks (RPE: 10-14) and 7-8 weeks (RPE: 11-16), with the Rating of Perceived Exertion (RPE) considering individual physical features.

**Measured item**

**Physical composition**

The study used the body composition analyzer (In-Body 720 Bio-Space Co., Korea) with bioelectrical impedance
analysis to investigate the height, weight, body fat, muscle quantity and body mass index of the subjects. All the subjects wore clothes as light as possible for accurate examination, removed metallic materials which impeded the current flow and refrained from ingesting water for 2 hours before the examination. The body composition examination measured the weight, body mass index and body fat ratio.

**Blood lipid metabolism and CK analysis**

The subjects fasted for more than 8 hours before blood analysis. The before analysis was performed before 24 hours of exercise. Also the after analysis was performed after 24 hours of exercise and the analysis was performed after more than 8 hours of fasting. 10ml of blood was sampled from the antecubital vein by an experienced specialist using a disposable syringe. The sampled blood was left at room temperature for 30 minutes and the serum was separated by centrifugation for 15 minutes at 3,500rpm. The separated serum was transferred to a special blood analysis company (SQLab, Seoul) to analyze the total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C) and creatine kinase (CK). The level of low-density lipoprotein cholesterol (LDL-C) was estimated using the equation below.

\[
\text{LDL-C} = \text{TC} - \text{HDL} - \frac{\text{TG}}{5}
\]

**Cytokine mRNA Expression from PBMC**

**PBMC isolation**

EDTA treated on approximately 4ml of blood sample to PBMC extraction, the same volume of PBS (phosphate-buffered saline) was added to dilute. And layered 4ml of Ficoll-Paque (Pharmacia, Sweden), then centrifuged 400 × g at room temperature for 20 min. The separated PBMC at the boundary between the blood and the Ficoll-Paque was obtained, then phosphate-buffered saline were added 2 times and washed to obtain pure PBMC.

**Total RNA extraction**

PBMC isolation and total RNA extraction is conducted by modified method of Pacifici et al. [35], the entire process was operated in a sterile condition. Total RNA was extracted from separated mononuclear cells through modified acid guanidinium-thiocyanate-phenol-chloroform extraction method [36] using RNAzol Kit (Guadinethiocyanate 4M, 2-metrcaptoethanol 0.1M, Phenol; TEL TEST INC., USA). Briefly, 0.5ml of RNAzol were put in PBMC to dissolve cells, 0.05ml chloroform was added and mixed on ice for 5 minutes, then centrifuged 12,000 × G at 4°C for 15 minutes. After centrifuge 0.5ml of isopropyl alcohol was added to the supernatant to extract total RNA, the extracted RNA was confirmed using a spectrophotometer. Finally extracted RNA was kept at -80°C in ethanol until the measurement.

**Complementary DNA (cDNA) synthesis by reverse transcription**

The cDNA synthesis was conducted using AccuPower RocketScript™ Cycle RT PreMix (Bioneer. KR). Each RNA preserved with 75% alcohol (-80°C) dried at room temperature for 15 minutes, it dissolved with 10 µl of DNase/RNase free double distilled water. According to the manufacturer's instructions, premix including components necessary to cyclic reverse transcription (CTRT) such as reverse transcriptase, oligo (dT) 20, dNTPs, reaction buffer and primers were added in RNA lysate, and DW was added to make the total amount of 20 µl, then cDNA was synthesize. The annealing conditions were at 37°C for 30 seconds, cDNA synthesis did at 50°C for 4 minutes, the reverse transcription reaction to remove secondary structure of RNA template was conducted for 30 seconds at 55°C and repeated 12 times. To confirm DNA extraction, DNA concentration was measured in eluent by A260/A280 ratio using spectrophotometer (ASP-2680, CellTA Gen, KR), then it was kept in -20°C.

**Real-time PCR**

To analyze cytokine mRNA, we performed cDNA amplifying by Real-time quantitative polymerase chain reaction (Real-time PCR). Cytokines measured in this study were TNF-α, IL-1β, IL-6 and INF-γ, and analyzed relative amount with glyceraldehyde 3-phosphate dehydrogenase (GAPDH) mRNA which is housekeeping gene. Forward primer and reverse primer which is react with synthesized cDNA in reverse transcription reaction were designed using Primer Express™ (Applied Biosystems, Foster, CA, USA), The following is PCR condition, 10 µl of Power SYBR Green PCR Master Mix (Applied Biosystems), 1 µl of 5pMol the forward primer and the reverse primer and 1 µl cDNA were added in each well, finally mixed with Diethylpyrocarbonate (DEPC) treated water, then we performed PCR with total amount of 20 µl solution. Pre-denaturation was done for 5 minutes at 95°C, and denaturation was conducted for 15 seconds at 95°C each cycle, annealing step was done at 59-60°C for 60 seconds and repeated 40 times, and then finally reaction at 65~95°C for 1-5 seconds per each step was performed to melt curve. For SYBR Green analysis, C1000 Thermal Cycler (CFX96 real-time system, Bio-Rad, US) was
Table 2. Pilates Exercise Program

| Variable                  | Pilates Exercise | RPE |
|---------------------------|------------------|-----|
| Warm Up (10min)           |                  |     |
| 1. breathing              | foamroller       |     |
| 2. spine articulation     | roll up/down     | 9-10|
|                           | neutral/imprint  |     |
|                           | thoracic massage|     |
| Pilates (50min–60min)     |                  |     |
| 1. half                   | foamroller/ball  | 10-11|
| 2. roll up                | rolling like a ball | 9-11|
| 3. the hundred            | neck roll down   | 10-11|
| 4. one leg circle         | straight leg     | 10-13|
| 5. swan/superman          | foamroller/ball  | 11-13|
| 6. leg stretch series     | single/double    | 12-15|
| 7. leg straight series    | single/double    | 12-15|
| 8. side/ front leg series | scissors, frog   |     |
|                           | hip circle/lift  | 9-16 |
| 9. open leg locker        | roll over/ jackknife |     |
| 10. rotator cuff          | abductor/adductor |     |
| 11. push up               | standing         | 10-16|
| Cool Down (10min)         |                  |     |
| 1. massage                | neck, spine, leg | 10-13|
|                           | QL, IT band      |     |
| 2. mermaid                | pelvis           | 9-12 |
| 3. side stretch           | shoulder circle  | 9-10 |
| 4. breathing              | 5 set            | 9-10 |

Table 3. Nucleotide sequence of primer in TNF-α, IL-6 and GAPDH mRNA

| Variable        | Sequence 1 | Sequence 2 | TM (°C) |
|-----------------|------------|------------|---------|
| TNF-α (+)       | 5'- TCC AGA CTT CCT TGA GAC ACG -3' | 5'- CCC GGT CTC CCA AAT AAA TAC -3' | 60 |
| TNF-α (-)       | 5'- CCC GGT CTC CCA AAT AAA TAC -3' | 5'- TCC AGA CTT CCT TGA GAC ACG -3' | 59 |
| IL-6 (+)        | 5'- GAT GAG TAC AAA AGT CCT GAT CCA -3' | 5'- CTG CAG CCA CTA GTT CTT GGT T -3' | 60 |
| IL-6 (-)        | 5'- CTG CAG CCA CTA GTT CTT GGT T -3' | 5'- GAT GAG TAC AAA AGT CCT GAT CCA -3' | 59 |
| GAPDH (+)       | 5'- CAA CGA CCA CTT TGT CAA GC -3' | 5'- GGT GGT CCA GGG GTC TTA CT -3' | 60 |
| GAPDH (-)       | 5'- GGT GGT CCA GGG GTC TTA CT -3' | 5'- CAA CGA CCA CTT TGT CAA GC -3' | 59 |

Table 4. Changes in Body Composition (M ± SD)

| Variables | Group | Pre   | Post  | △(%) | F    | P    |
|-----------|-------|-------|-------|------|------|------|
| Weight (kg) | PEG (n = 9) | 53.56 ± 9.59 | 52.60 ± 9.04 | -1.63 | G:0.007 | G: .933 |
|           | NEG (n = 9) | 53.51 ± 9.03 | 53.39 ± 9.64 | -0.33 | T:2.332 | T: .146 |
|           |          |       |       |      | GT: 1.563 | GT: .255 |
| Fat (%)   | PEG (n = 9) | 27.72 ± 5.03 | 30.61 ± 3.92 | 11.71 | G:2.502 | G: .133 |
|           | NEG (n = 9) | 24.58 ± 4.83 | 27.10 ± 4.78 | 11.23 | T:18.274 | T: .001 |
|           |          |       |       |      | GT: 0.084 | GT: .776 |
| BMI (kg/㎡) | PEG (n = 9) | 21.29 ± 2.47 | 20.96 ± 2.43 | -1.52 | G:0.763 | G: .395 |
|           | NEG (n = 9) | 20.18 ± 2.24 | 20.11 ± 2.43 | -0.38 | T:1.694 | T: .211 |
|           |          |       |       |      | GT: 0.753 | GT: .398 |

△(%) = rate of change, BMI: Body Mass Index
G: Group, T: Time, GT: Group*Time
PEG: Pilates Exercise Group, NEG: Non Exercise Group

**RESULTS**

Table 4 shows the impact of the 8-week Pilates exercise on blood lipid and inflammatory cytokine mRNA changes.
Table 5. Changes In Serum Lipid Levels and CK (M ± SD)

| Variables | Group    | Pre         | Post        | △(%)       | F     | P     |
|-----------|----------|-------------|-------------|------------|-------|-------|
| Cholesterol (mg/dl) | PEG (n = 9) | 166.67 ± 15.94 | 170.55 ± 27.05 | 2.23 | G: 4.856 | T: .067 |
|           | NEG (n = 9) | 150 ± 30.93  | 143.22 ± 20.31 | -11.95 | GT: 0.913 | G: .354 |
| HDL-C (mg/dl) | PEG (n = 9) | 53.78 ± 8.07  | 58.00 ± 8.99   | 8.55  | G: 0.104 | T: .023 |
|           | NEG (n = 9) | 59.22 ± 14.20 | 55.56 ± 10.21  | -13.95 | GT: 4.556 | G: .049 |
| LDL-C (mg/dl) | PEG (n = 9) | 96.56 ± 19.45 | 100.69 ± 27.38 | 3.33  | G: 5.836 | T: .245 |
|           | NEG (n = 9) | 75.31 ± 19.52 | 74.93 ± 21.32  | -6.60  | GT: 0.274 | G: .608 |
| Triglyceride (mg/dl) | PEG (n = 9) | 81.67 ± 28.8 | 59.33 ± 17.85  | -20.75 | G: 0.000 | T: .056 |
|           | NEG (n = 9) | 77.33 ± 37.88 | 63.66 ± 18.34  | -21.33 | GT: 0.247 | G: .626 |
| CK        | PEG (n = 9) | 63.33 ± 19.90 | 119.11 ± 64.92 | 95.51  | G: 2.102 | T: .044 |
|           | NEG (n = 9) | 76.89 ± 13.24 | 67.45 ± 18.79  | -19.29 | GT: 9.432 | G: .007 |

△(%) = rate of change
G: Group, T: Time, GT: Group*Time
PEG: Pilates Exercise Group, NEG: Non Exercise Group

Table 6. Chang In Inflammatory Factors (M ± SD)

| Variables | Group    | Pre         | Post        | △(%)       | F     | P     |
|-----------|----------|-------------|-------------|------------|-------|-------|
| IL-6      | PEG (n = 9) | 0.48 ± 0.51 | 0.74 ± 0.46 | 207.64 | G: 0.001 | T: .183 |
|           | NEG (n = 9) | 0.49 ± 0.76 | 0.72 ± 0.59 | 339.32 | GT: 0.006 | G: .978 |
| TNF-α     | PEG (n = 9) | 0.14 ± 0.05 | 0.61 ± 0.32 | 407.96 | G: 0.164 | T: .582 |
|           | NEG (n = 9) | 0.16 ± 0.14 | 0.49 ± 0.59 | 338.68 | GT: 0.247 | G: .007 |

△(%) = rate of change
G: Group, T: Time, GT: Group*Time
PEG: Pilates Exercise Group, NEG: Non Exercise Group

Body composition change
<Table 4> shows the measurements of body composition (weight, body fat ratio, body mass index) for the 8-week Pilates exercise group and the control group. Weight analysis showed the tendency for a decrease in bodyweight in both the exercise and control groups but no significance. Body fat ratio analysis showed a significant increase in both the exercise and control groups (p < 0.001) but no interaction effect was observed. The body mass index analysis showed a decrease in both the exercise and control groups but no significant difference.

Blood lipid metabolism and creatine kinase (CK) change
<Table 5> shows the measurement of blood lipid metabolism and CK changes in the exercise and control groups for the 8-week Pilates exercise study. Analysis of blood HDL-C changes showed a group × time interaction effect (p < 0.05) and a particular increase in the HDL-C level after Pilates exercise. The blood TC and LDL-C increased significantly in the exercise group (p < 0.05) but failed to demonstrate an interaction effect. The change in TG showed no group × time interaction effect either. The blood CK, on the other hand, showed a group × time interaction effect (p < 0.01), with a decrease in the control group and a 1.9x increase in the Pilates exercise group.

Inflammatory cytokine mRNA change
<Table 6> shows the result of the blood inflammatory cytokine analysis in the Pilates exercise and control groups after the 8-week Pilates exercise program. Analysis of IL-6 mRNA levels in the blood showed no group × time interaction effect. Analysis of TNF-α mRNA levels in the blood showed a significant increase over time (p < 0.05) but no interaction effect was found for group × time.

DISCUSSION
It has been reported that various types of exercise positively affect health and benefit physical improvement. Pilates
emerged recently in the US and has gained popularity with many people in Korea [25,35]. The purpose of this study is to clarify the impact of 8 weeks of Pilates exercise on body composition, blood lipid and inflammatory cytokine mRNA in female undergraduates and to investigate the utility of the Pilates exercise program in the future. The result shows that bodyweight did not change but body fat ratio increased after the 8-week Pilates exercise. However, the body fat ratio increase was found in the control group as well. It may be inferred that the increase was not from the Pilates exercise but was due to poor control of the nutritional and dietary habits of female undergraduates in their 20s during the 8 week period. Park et al. [33] reported that there were no significant differences in bodyweight, body fat ratio and Waist Hip Ratio (WHR) during their study on the impact of 12 weeks of Pilates exercise using a mat on the body composition, blood lipid and blood pressure of 30 female undergraduates. Choi et al. [9] reported that no significant difference was found in the bodyweight and body fat of subjects participating in Pilates exercise 5 times a week for a period of 16 weeks. These data indicate that the type of exercise affects the results. It is judged that the Pilates exercise in the present study qualifies as highly intensive exercise which may cause muscle damage unlike the aerobic exercise performed in prior studies. A previous study performed by the authors on seniors [6] showed a 1.4x increase in the CK index after one-time Pilates exercise, indicating that the exercise was vigorous enough to cause muscle damage. The current study found that the CK index increased by about 1.9 times after 8 weeks of Pilates exercise. This shows that Pilates exercise is an intensive exercise robust enough to cause damage to muscles. In addition, fascia massage using the foam roller directly stimulates the muscle. It is likely that the muscular stimulation affected the CK index, causing the muscle damage marker index to increase during Pilates exercise, particularly when using the Pilates tool. That is, Pilates exercise with the form roller directly stimulates the muscles and the stimulation results in muscle damage. CK is the major enzyme that controls the ATP-PC system, an indicator that indirectly reflects metabolism in muscle cells and may be used as a marker that indicates the degree of body and muscle damage based on the increase in activation resulting from physical exercise [40]. Kim et al. [26] reported that the CK concentration increased significantly after exercise when comparing the concentration before the exercise to the concentration during the restoration period after intensive running. Yoon et al. [41] stated that the CK concentration significantly increased right after maximum exercise. The present study confirmed that the CK concentration significantly increased after Pilates exercise, demonstrating that the exercise affected the muscles and caused muscle damage. This means that the Pilates exercise employed in the present study was intensive enough to damage the muscles and the damage led to inflammation and the expression of inflammatory cytokine mRNA. In addition, it was concluded that changes in the experimental environment including poor control over the energy intake, seasonal fluctuation, instrumental error and the menstrual cycle of the female subjects had an effect on body fat, highlighting the importance of strict control over the nutritional intake and experimental conditions.

Meanwhile, Kondo [22] reported that the decrease in body fat ratio positively affected lipid metabolism. Wallace et al. [40] reported that increased body fat caused an increase in LDL-C and TG concentrations and a decrease in HDL-C concentration, which is a direct cause of cardiovascular disease. The results of this study confirmed that the exercise group showed significant increases in blood HDL-C concentration despite an increase in the body fat ratio, implying that the Pilates exercise was effective in increasing blood lipid metabolism, particularly with increasing the concentration of HDL-C, despite the body fat ratio increase. However, the study failed to verify that the exercise positively affected the TC, TG and LDL-C concentration decrease. Kim et al. [30] reported an interaction effect where TC levels significantly decreased in middle-aged women with more than 30% body fat ratio undertaking Pilates exercise for 90 minutes a day, 3 times a week over a period of 10 weeks and that their TG levels significantly dropped during that time frame. Choi [9] verified the interaction effect with TC, TG and LDL-C concentrations significantly decreasing after 60 minutes of Pilates exercise a day, 5 times a week for 24 weeks. HDL-C levels also increased significantly among the study subjects, who were all senior women. In addition, Kim et al. [27] reported that TG concentrations significantly dropped while HDL-C significantly increased in the exercise group consisting of obese female undergraduates undergoing Pilates exercise for 60 minutes a day, 3 times a week for 10 weeks. These results are directly opposite to the results of the current study but it is estimated that the reason for the significant differences in lipid metabolism was due to the studies using obese subjects or providing long-term Pilates exercise for seniors. However, as reported in the previous study, Pilates exercise reduced body fat ratio and positively affected lipid metabolism. Next studies will investigate the use of aerobic Pilates exercise to reduce body fat ratio and focus on the effect of Pilates exercise on blood lipid metabolism.

Meanwhile, the study showed an increase in the concentration of IL-6 mRNA but without statistical significance,
which makes it difficult to conclusively state that the Pilates exercise affected IL-6 levels in the female undergraduates. However, a study by Park et al. [33] which provided long-term Pilates exercise for more than 8 weeks reported that IL-6 levels significantly dropped after complex aerobic and muscular exercise for obese women in their 40s. Kim [23] stated that the blood IL-6 concentrations of the exercise group decreased compared to their counterparts in the obese group. As demonstrated by the studies above, there is a possibility that long-term Pilates exercise decreases blood IL-6 concentrations but the studies did not confirm. Considering that prior studies closely linked lipid metabolism to IL-6 concentration, it is expected that the impact of Pilates exercise on the IL-6 concentration of female undergraduates with high body fat ratio would be different. Investigating the impact of Pilates exercise on IL-6 concentration depending on the obesity of the subject will likely provide meaningful results. It is known that the inflammatory cytokine TNF-α significantly influences body fat increase and muscle decrease as it is secreted from the fat and muscle tissues in conjunction with IL-6. Kondo et al. [22] reported that the blood TNF-α level was significantly reduced by jogging, walking, muscle exercise, stretching, speed rope and cycling for 30 - 60 minutes for 4 - 5 times a week over a period of 7 months with 60 - 70% of the HRR among obese women with an average age of 18. Brunn et al. [4] reported that low diet and regular exercise improved inflammation through a significant decrease in the blood TNF-α concentration of 27 highly obese women. Kern et al. [21] reported a TNF-α drop as well as body fat decrease by implementing a weight loss program with 39 obese people. Unlike the results of the studies above, this study showed an increase in TNF-α concentration after Pilates exercise. Pedersen et al. [23] reported that weight control and mid-level exercise training reduced TNF-α concentration in fat tissue and skeletal muscles and was effective in improving insulin resistance. However, intense exercise caused an inflammatory reaction and increased the blood TNF-α concentration of the test subjects. Petersen et al. [35] also reported that the TNF-α concentration rose after extended highly intense exercise. This suggests that the Pilates exercise employed in the present study was intense enough to increase the TNF-α concentration. This conclusion is supported by the observation of significant increase in blood CK concentration after Pilates exercise compared to before the exercise.

In addition, environmental factors and nutritional aspects related to dietary habit were instrumental in increasing body fat ratio after Pilates exercise compared to before the exercise. This suggests that the aerobic component provided by mat Pilates exercise is required. Most people participate in Pilates exercise to lose body fat. A lot of prior studies on Pilates exercise adhere to traditional Pilates programs for rehabilitation or muscle exercise. However, it is suggested that future studies should be performed using a Pilates program that encompasses proper aerobic exercise under thorough analysis for myology.

CONCLUSION

The study which investigated the impact of the 8-week Pilates exercise on the body composition, blood lipid metabolism and inflammatory cytokine expression for the exercise group and control group showed that the Pilates exercise increased the CK and highly affected the muscle to cause damage, did not affect the body fat ratio decrease but was effective in increasing the HDL-C concentration. It is judged that the Pilates exercise in the study was insufficient to improve the obese and blood lipid metabolism due to the failure in exerting positive impact on the TC, TG, LDL-C and inflammatory cytokine mRNA expression. Therefore, it is judged to modify the Pilates exercise program for the exercise purpose and in particular, it is considered that it is required to develop the Pilates exercise program for the purpose of the body fat decrease and lipid metabolism improvement.

REFERENCES

[1] Baek Hee-Young, Kim Dong-Whan (2012). The Effects of Pilates Exercise Program Using Multimedia on Body Balance and Physical Self-Efficacy of Mid-age Women. The Korea Journal of Sport Science, 21(1):603-614.
[2] Boardley D., Fahlman M., Topp R., Morgan A. L., McNevin N. (2007). The impact of exercise training on blood lipids in older adults. The American Journal of Geriatric Cardiology, 16(1):30-35.
[3] Brancaccio P, Maffulli N, Limongelli FM. (2007). Creatine kinase monitoring in sport medicine. British Medical Bulletin, 81-82:209-230.
[4] Brunn JM., Jorn W. Helge, Bjorn Richelsen, Bente Stallknecht (2006). Diet and exercise reduce low-grade inflammation and macrophage infiltration in adipose tissue but not in skeletal muscle in severely obese subjects. American Journal of Physiology, 292:E961-E967.
[5] Cha, Seong-Woong (2007). The effect of Pilates Mat Exercise on Body Composition and Mineral Density in...
Pilates exercise on lipid metabolism and inflammatory cytokines mRNA expression

Middle-aged Women. Journal of Korea Sport Research, 18(6):945-953.

[6] Chang Sun Kim, Ji Yeon Kim, Hyo Jin Kim (2014). The effects of a single bout Pilates exercise on mRNA expression of bone metabolic cytokines in osteopenia women. Journal JENB, 18(1), 69-78.

[7] Clarkson PM, Hubal M.J. (2002) Exercise-Induced Muscle Damage in Humans. American Journal of Physical Medicine Rehabilitation, 81(Suppl):52-69.

[8] Cho, Hyun-Choul, Yang, Sang-Hoon, Kim, Jong-Shik (2014). The effects of Obese adolescents’ Judo training on PAPS Health fitness, Inflammatory factor TNF-ɑ, and IL-6. Korea Society for Wellness, 9(2):189-198.

[9] Choi, Bong Hwa, Kim, Chang Hwan (2006). Effect of Pilates Mat Exercise on Low Back Pain, Lumbar Muscular Strength of Elderly, Pain Scale and Body Composition. Journal of Korea Sport Research, 17(5):633-641.

[10] Choi, Pil-Byug (2012). The effect of Pilates mat gym program on Blood pressure, heart rate and lipids profile in elderly women with hypertension. The Korea Journal of Sport Science, 21(2):893-903.

[11] Das, U. N. (2004). Anti-inflammatory nature of exercise. Nutrition, 20(2):323-326.

[12] Herrington, L., Davies, R (2005). The influence of Pilates training on the ability to contract the Transversus Abdominis muscle in asymptomatic individuals. Journal of Bodywork and Movement Therapies, Elsevier, 9(1):52-57.

[13] Ho Jun Kwon, Nam Jung Kim, Yong Chul Choi, Sun Hur (2013). Effect of the Pilates Exercise on Metabolic Hormone, Atherosclerosis Indices and Coronary Artery Disease Risk Factors in Women Hemiplegia Stroke Patients. The Korean Society of Sport and Leisure Studies, 53:757-768.

[14] Jae Gu Kim (2011). Effects of Yoga Exercise Programme on the Serum Lipid Profile and Inflammatory Markers of Elderly. The Korean Society of Sport and Leisure Studies, 44(2):585-591.

[15] Jae S. Y., Fernhall B., Heffernan K. S., Jeong M., Chun E. M., Sung J., Lee S. H., Lim Y. J., Park W. H. (2006). Effects of lifestyle modifications on C-reactive protein: contribution of weight loss and improved aerobic capacity. metabolism clinical and experimental, 55(6):825-31.

[16] Joseph E, Simona Cipriani (2004). Pilates and the "powerhouse". 7, Long Ridge Road, Redding, CT 06896, USA.

[17] Ji-Eun Jang, Yong-Kwon Yoo, Byung-Hoon Lee (2013). The Changes of the body composition and vascular flexibility According to Pilates mat Exercise during 12 weeks in elderly women. The Korea Institute of Electronic Communication Sciences, 8(11):1777-1783.

[18] Jin Hwan Yoon, Sung Hu Shin, Sung Soo Kim (1993). The Responses of Serum Creatine Kinase (CK) following maximal Exercise. Journal of Sports Culture Science, 4(1):94-105.

[19] Jun, Hong-Jo, Lee, Ji-Hee (2007). The effects of Pilates methods on physical self-concepts and emotion in adults. Korean Journal of Dance Education, 7(1): 65-74.

[20] Jun, Hong-Jo, Hwang, Kyu-Ja (2012). The Effects of 12 Weeks of Pilates Exercise on Body Composition, Pelvis and Vertebra Posture in Ballerina Dancers. Korean Journal of Dance Education, 12(1):1-10.

[21] Kern, Saghizad, Ong, Bosch, Deem, Simsoło (1995). The expression of tumor necrosis factor in human adipose tissue. Regulation by obesity, weight loss, loss, and relationship to lipoprotein ilpase. The journal of clinical investigation, 95(5).

[22] Kondo R, Higuchi M, Takahashi M, Oie M, Tanaka Y, Gejyo F, Fujii M. (2006). Human T-cell leukemia virus type 2 Tax protein induces interleukin 2-independent growth in a T-cell line. Retrovirology, 2, 3:88.

[23] Ki Jin Kim (2008). The associations of obesity and exercise participation with body composition, blood reveals of IL-6 and TNF-a in adult women. Korean Society of Exercise Physiology, 17(2):119-128.

[24] Kim, Kyung-Tae, Joe, Ji-Hoon (2013). Effects of Elastic Band and Aerobic Exercise on Fitness, Blood Lipids, and Vascular Inflammatory Markers in Elderly Women, Korean Association of Sport and Certified Professionals, 15(2):129-138.

[25] Kim, Do-Yeon, Eun, Seon-Deok, Kim, Yong-Woon, Lee, Seong-Cheol (2011). The effect of Pilates training on spinal motion pattern. Korea Journal of Exercise Rehabilitation, 8(3):61-71.

[26] Kim, Jae-Won, Han, Mi- Kyung, Chang, Jae-Keun (2006). The Analysis of the Movement of Hormone and Creatine Kinase in Blood during the Recovery Period after an Intense Running. Journal of Korea Sport Research, 17(5):41-46.

[27] Kim, Yoon-Hee (2012).Effects of Participation in Pilates Exercise on Obesity Degree, Blood Lipid Level, and Self-Esteem in Obese Female University Students. Korean Journal of Dance Education, 12(2):73-81.

[28] Nam Jung Kim (2011). Effects of Elastic Band and Pilates Exercise on BMD and Body Composition in Office Working Women. Korea Physical Education Association for Girls and Women, 25(2):13-22.

[29] Nam Sang-Nam, Kim Jong-Hyuck, Kim Hey-Jin, Kim
Il-Kon, Park Jin-Hong (2007). The Effect of 12 Weeks Pilates Met Exercise on the Blood Lipids in Middle-aged Women. The Korea Journal of Sport Science, 16(4):781-793.

[30] Nam Jung Kim, Won Il Son, Bock Hwan Lee (2009). Effects of Pilates mat exercise and detraining on metabolic hormone and coronary artery disease risk factor in obese middle aged women. Korean Society of Exercise Physiology, 18(1):65-74.

[31] Nicklas, B. J., Ambrosius, W., Messier, S. P., Miller, G. D., Penninx, B. W., Loeser, R. F., Palla, S., Bleecker, E., & Pahor, M. (2004). Diet-induced weight loss, exercise, and chronic inflammation in older, obese adults: a randomized controlled clinical trial. The American Journal of Clinical Nutrition, 79(4):544-51.

[32] Pedersen, B. K., Bruunsgaard, H., Ostrowski, K., Krabbe, K., Hansen, H., Krzywkowski, K., Toft, A., Sondergaard, S. R., Petersen, E. W., Ibfelt, T., & Schjerling, P. (2000). Cytokines in aging and exercise. International Journal of Sports Medicine, 21:4-9.

[33] Park, Sang-Kab Kim, Eun-Hee Kwon, Yoo-Chan (2006). The Effects of Combined Training on Self-reliance Fitness and Risk Factors of Metabolic Syndrome in The older Women. The Korean Journal of Growth and Development, 14(2):37-48.

[34] Park, Seoung-Soon, Kwon, Jeong-Hyun (2011). The Effect of 12weeks Culture Physical Education Pilates Exercise on the Body Composition and Blood Lipids, Blood Pressure in Women College Students. The Korea Journal of Sport Science, 20(6):1261-1269.

[35] Petersen, A. M., & Pedersen, B. K. (2005). The anti-inflammatory effect of exercise. Journal of applied physiology, 98(4):1154-1162.

[36] Segal NA, Hein J, Basford JR (2004). The effects of Pilates training on flexibility and body composition: an observational study. Arch Phys Med Rehabil, 85:1977-81.

[37] Seung Ho Yoon, Gyong Hea Park, Sung Won Yoon (2007). Effect of 12 week of Pilates Exercise on Flexibility, Muscular Strength and Body Composition of University Women Students. The Korean Journal of Sport Science, 18(1):1-8.

[38] Siler B (2000). The Pilates Body. New York, NY: Broadway Books.

[39] Taylor A. H., Cable N. T., Faulkner G., Hillsdon M., Narici M., Van Der Bij A. K. (2004). Physical activity and older adults: a review of health benefits and the effectiveness of interventions. Journal of Sports Sciences, 22(8):703-725.

[40] Wallace MB, Mills BD, Browning CL (1997). Effects of cross-training on markers of insulin resistance/hyperinsulinemia. Medicine and Science in Sports and Exercise, 29(9):1170-1175

[41] Yoon, Jong Kwan (1998). The Effects of Maximal Exercise on Serum Creatine Kinase and Lactate Dehydrogenase. The Korean Society of Sports Medicine, 16(2):277-281.

[42] Yoon Jung Shin, Yoon Seun Oh, Ki Jin Kim (2004). Change of Blood Concentration of Metabolites, Hormone, and Cytokines after Dancesports Program of 10 Weeks in Obese Women. The Korean Journal of Physical Education, 43(6):467-479.