

Original Article

Effects of oat bran and jogging on aerobic capacity, lipid profile and antioxidant parameters in young sedentary males

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Abstract:

Problem Statement: Sedentary lifestyle predispose an individual to a number of chronic disease. Adopting a physically healthy lifestyle along with a consumption of nutritional supplementation is a strategy towards improving health related quality of life. **Purpose:** We aimed to investigate the combined effects of oat bran consumption and jogging exercise on aerobic capacity, lipid profile and antioxidant status in young sedentary males. **Methods:** Forty seven sedentary male university students with mean age 20.9 ± 1.7 years were recruited. They were randomly assigned to sedentary control (C), oat bran supplementation alone (O), exercise alone (J) and combined oat bran and exercise (OJ) groups. The participants in O and OJ groups consumed 18 g of oat bran powder which contains 3.6 g of β -glucan daily for 8 weeks. The participants in J and OJ groups performed jogging exercise with moderate intensity, i.e. 55% to 70% of their age-predicted HR_{max} , 30 min per day, 3 days per week for 8 weeks. Participants' body composition, predicted maximal oxygen consumption (VO_{2max}), lipid profile and antioxidant status were measured pre- and post-tests. **Results:** In the O group, there were significant decreases in total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), increase in superoxide dismutase (SOD) activity and decrease in glutathione peroxidase (GPx) activity. In the J group, there were a significant increase in predicted VO_{2max} and decreases in TC and LDL-C. In the OJ group, there were significant decrease in percentage of body fat, increase in predicted VO_{2max} , high-density lipoprotein cholesterol (HDL-C) and SOD activity, and decreases in triglycerides (TG) and LDL-C. **Conclusions:** Eight weeks of regular jogging exercise combined with daily oat bran consumption elicited more beneficial effects on improving body composition, aerobic capacity, lipid profiles and SOD activity in young sedentary males.

Key words: body composition, aerobic capacity, antioxidant parameteres

Introduction

Body triglycerides come from excess dietary carbohydrate, proteins and fats which are converted into triglycerides. Whereas, cholesterol comes from meat-based food such as eggs or beef. The liver also synthesises its own cholesterol from the saturated fat directly. High intake of dietary fat can also indirectly stimulate reabsorption of cholesterol back into the blood, increasing blood cholesterol level. Lipids are hydrophobic molecules and therefore they form a complex with protein, known as lipoproteins, in order to be soluble and able to be transported in the blood (McArdle et al., 2010; National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), 2002; Tortora & Derrickson, 2009). Three major lipoproteins - very-low density lipoproteins (VLDL), low-density lipoproteins (LDL) and high density lipoprotein (HDL) are detected in the fasting serum. VLDL particles are triglyceride-rich lipoproteins and elevated serum triglycerides is an independent risk factor for coronary artery disease (CHD). LDL cholesterol contributes 60-70% of the total serum cholesterol. Elevated serum LDL cholesterol level is associated with atherosclerosis while HDL cholesterol protects against the development of atherosclerosis (NCEP ATP III, 2002).

Free radicals can influence our body system either positively or negatively. In immune system, neutrophils and macrophages release free radicals to destroy foreign substances as part of the body's defence mechanism. On the other hand, free radicals can alter the structures of lipid, protein and DNA (Finaud et al., 2006; Tortora & Derrickson, 2009). Antioxidants are the compounds that can suppress free radicals and their damaging effects. If there is an imbalance between the actions of antioxidants and free radicals, it will lead to an oxidative stress state such as cell impairment (Sen, 2001). Oxidative stress has been known as the source of human aging and leads to the accumulation of major age-related diseases (Dato et al., 2013). Reactive oxygen species (ROS) is one type of the free radicals. There are a few locations or sources of ROS production. For example, production of energy or adenosine triphosphate (ATP) in mitochondria for muscle contraction during exercise is also associated with ROS production which in turn can expose the mitochondria to oxidative stress damage (Finaud et al., 2006).

Previous studies have shown that improper diet and sedentary lifestyle contribute to detrimental health effect such as coronary artery disease (CAD) (Lakka et al., 2003; McArdle et al., 2010; Plowman & Smith, 2006; Yusuf et al., 2001). These two causal factors lead to high cholesterol levels and oxidative stress imbalance in the body over time, and eventually increase the risk of CAD (McArdle et al., 2010; Plowman & Smith, 2006; Stocker & Keaney, 2004; Weiss & Landauer, 2003; Yusuf et al., 2001). Moreover, previous studies have also reported that sedentary living with less physical activity can also result in atrophy of muscle proteins (Powers et al., 2012; Powers et al., 2007) and lowered cardiorespiratory fitness at the same time (Lakka et al., 2003). Improper diet and a sedentary lifestyle are among the modifiable risk factors which can be avoided or prevented (NCEP ATP III, 2002). Thus, a simple strategy to improve the health-related quality of life among the public is to change the lifestyle by adopting a physically active lifestyle while consuming adequate nutrition (Anderson & Gustafson, 1988; Anderson et al., 1984; Anderson et al., 1991; Bartram et al., 1992), and it is believed that the cholesterol-lowering effect is mainly due to the action of β -glucan (Davidson et al., 1991). The US Food and Drug Administration (1997) recommended that an individual consumes 3 g of β -glucan daily to reduce the risk of coronary heart disease (CHD). NCEP ATP III (2002) also suggested to include food with high viscous fibre content to reduce one's LDL-cholesterol (LDL-C) levels.

Antioxidant supplementation has been reported to have potential to reduce oxidative damage in the body (Finaud et al., 2006; Powers, 2014). Phytochemical study revealed that oat bran has been shown to contain phenolic substances (Serea & Barna, 2011). In addition, short term consumption of avenanthramides phenolic extracts from oat bran can increase the antioxidant capacity in humans (Chen et al., 2007). Therefore, it is speculated that oat bran possesses antioxidant potential due to phenolic contents and its consumption can increase the antioxidant capacity in the body.

Exercise is regarded as a powerful tool to maintain optimum physical health and longevity. In contrast, sedentary lifestyles with lack of exercise, smoking and having high blood cholesterol level can increase one susceptibility of getting heart diseases (McArdle et al., 2010). Performing higher physical activity or aerobic exercise alone has been proven to increase cardiovascular fitness (Kemmler et al., 2004; Suter et al., 1994) and improve lipid profile (Isler et al., 2001; Kannan et al., 2014). Performing exercise can also improve antioxidant adaptation (Goon et al., 2009; Onur et al., 2011) and reduce oxidative damage markers (Goon et al., 2009). In order to transform exercise into a top priority, the exercise chosen should be enjoyable and something that can be maintained so that it can be turned into a healthy lifestyle later (American College of Sports Medicine, 2009; Lavie, 2007). According to American College of Sports Medicine (2010), the exercise recommendation framework for frequency, intensity, time of exercise and type of exercise for sedentary healthy adults are 3 to 5 days per week, 57% to 67% of predicted maximum heart rate (HR_{max}), 20 to 30 minutes per day/60 to 150 min per week, with walking, jogging, stepping and cycling exercise. Jogging as an aerobic exercise can be easily performed almost anywhere either indoors or outdoors. As for the clothing, only a good pair of shoes is important to prevent injury.

To date, no studies have investigated the combined effect of oat bran with jogging exercise on aerobic capacity, lipid profiles and antioxidant status. Therefore, the present study was carried out to investigate the additional beneficial effects of combined oat bran consumption and jogging exercise compared to the effect of oat bran consumption alone, exercise alone, or sedentary lifestyles without oat bran consumption and exercise on aerobic capacity, lipid profiles and antioxidant status. The findings of the present study can be proposed as a guideline in planning exercise and nutritional programmes for the young sedentary male population.

Material & methods

Participants

Forty eight healthy, sedentary male volunteers with age ranging from 18-25 years old were recruited among Universiti Sains Malaysia students. The participants were non-smokers, did not participate in any form of exercise programme and did not exercise more than once a week prior to the study; did not consume oat bran or any oat products more than twice a week; and had not been consuming calcium or vitamin supplements. The participants were cleared to engage with the exercise training programme, confirmed by a Physical Activity Readiness Questionnaire (PAR-Q). Subjects who satisfied the inclusion criteria provided their written informed consent. The present study was approved by the Human Research Ethics Committee of Universiti Sains Malaysia (JEPeM code: USM/JEPeM/15050158).

Experimental Design

The participants were aged and body weight-matched and then randomly assigned into four different groups, with 12 participants per group. The groups were control group without oat bran supplementation and jogging exercise (C), oat bran supplementation alone group (O), jogging exercise alone group (J) and combined oat bran supplementation and jogging exercise group (OJ). Before and after 8 weeks of experimental study, i.e. at pre- and post-tests, anthropometric and physiological characteristics and predicted VO_{2max} of the participants were measured. Blood samples were collected for determining lipid profile and antioxidant status.

The oat bran powder supplements were provided by Summit Company (Malaysia) Sdn Bhd. The participants in the O and OJ groups were required to consume 18 g of oat bran powder which contains 3.6 g of β -glucan (Summit Company (Malaysia) Sdn Bhd, 2012; US Food and Drug Administration, 1997) daily for 8 weeks. The oat bran powder needed to be diluted with 250 ml of plain water and consumed as a drink. The participants were required to take the oat bran powder two times, 9 g in the morning and 9 g at night. On the day of exercise, the participants in OJ group had to take 9 g in the morning and 9 g an hour before commencing the jogging session.

Participants in the J and OJ groups performed jogging exercise 3 times a week for 8 weeks. During the jogging, the heart rate intensity was set at 55% to 70% of their respective age-predicted HR_{max} . The estimated targeted range of exercise heart rate of the participants ranged from 110 bpm to 140 bpm. Meanwhile, the estimated jogging pace was approximately 4.5 mph and the estimated calorie burn during exercise was approximately equivalent to 171 kcal. Prior to each jogging session, 5 minutes warm up activities were performed, followed by 30 minutes of jogging exercise and subsequently 5 minutes of cooling down. Post-exercise heart rate of the participants was counted immediately determined after each jogging session.

Measurements of Anthropometric Parameters

Anthropometric parameters such as body height, body weight, body mass index (BMI) and percentage of body fat were measured at pre- and post-tests. A stadiometer (Seca 220, Germany) was used to measure body height to the nearest 0.01 m. A body composition analyser (TANITA, model TBF-410, Japan) was used to measure body weight and percentage of body composition to the nearest 0.1 kg and 0.1% respectively. Height and weight measurement were taken in light clothing without shoes. Blood pressure was measured using an automated blood pressure monitor (A&D, Model TM-2540, Japan) in a relaxed sitting position.

Blood Sampling

Blood samples were taken at pre- and post-tests. Participants were required to fast overnight from 11.00 p.m. to 9.00 a.m. Seven mL of blood was drawn from the antecubital vein and collected in a clotting activator tube. The blood samples were centrifuged for 10 minutes at 4000 rpm at 4°C (Hettich Zentrifuger-Rotina 46RS, Germany). Serum was separated and stored into aliquot at -80°C freezer (ThermoForma Model 705, USA) for further biochemical analyses.

Blood Biochemical Analysis

Serum samples were analyzed for serum total calcium (Ca) and bone turnover markers which included serum alkaline phosphatase (ALP) and serum osteocalcin (OC) as bone formation markers, and serum carboxyterminal telopeptide of type 1 collagen (CTX-1) as a bone resorption marker. Serum total Ca concentration and serum ALP activity analysis were performed in an accredited pathology laboratory (BP Clinical Lab, Malaysia). Serum OC concentration and CTX-1 concentration were analyzed using a commercial kit, N-MID Osteocalcin ELISA kit (ImmunoDiagnosticSystems, UK) and human C-telopeptide of type 1 collagen (CTX-1) ELISA kit (Qayee-Bio, China) respectively according to manufacturer's instructions and measured on VersaMax ELISA microplate reader (Molecular Devices, USA) in the laboratory in Universiti Sains Malaysia.

Statistical Analysis

The collected data was analysed using statistical software of Statistical Package for Social Sciences (SPSS) Version 21.0. Significant difference was accepted at $p < 0.05$. One-way ANOVA was performed to ensure there was no significant difference in age and body weight among the four experimental groups at the beginning of the study. Repeated measures ANOVA was executed to determine the significant level of time-group interaction and significant difference of all measured parameters between and within groups. Study results are presented as means \pm standard deviations (mean \pm SD).

Results

Out of the 48 participants enrolled at the beginning of the study, 47 participants with mean age of 20.9 ± 1.7 years, mean body weight of 60.0 ± 10.7 kg, mean body height of 1.68 ± 0.06 m and mean body mass index (BMI) of 21.5 ± 4.0 $kg \cdot m^{-2}$ completed the present study. One participants from control group dropped out due to personal reasons. Means body weight of the participants according to group at pre-test were C: 58.5 ± 8.9 kg, O: 61.3 ± 11.4 kg, J: 57.1 ± 7.7 kg and OJ: 63.0 ± 13.8 kg. The means age of the participants in C, O, J and OJ group was 21.1 ± 1.9 years, 22.4 ± 1.1 years, 19.9 ± 1.7 years and 20.3 ± 0.87 years respectively. The means body height of the participants at pre-test were C: 1.71 ± 0.06 m, O: 1.68 ± 0.06 m, J: 1.67 ± 0.06 m and OJ: 1.68 ± 0.07 m. Means BMI of the participants at pre-test were C: 21.8 ± 4.7 $kg \cdot m^{-2}$, O: 21.6 ± 3.7 $kg \cdot m^{-2}$, J: 20.3 ± 2.6 $kg \cdot m^{-2}$ and OJ: 22.3 ± 4.4 $kg \cdot m^{-2}$. There were no significant differences in body weight, body height and BMI among the groups at pre-test. In the post-test, means body weight of the participants of each group was C: 58.7 ± 8.4 kg, O: 61.5 ± 11.4 kg, J: 57.8 ± 7.4 kg and OJ: 62.0 ± 12.5 kg. After 8 weeks of experimental period, results showed that there were no significant time-group interaction ($df=3$, $F=1.76$, $p=0.170$) on body weight. The percent changes of body weight in OJ group was the highest (-1.6%) among the groups. The percent change in other groups was C: +0.3%, O: +0.3%, and J: +1.2% respectively.

Fig. 1 shows the percentages of body fat of all the groups at pre- and post-tests. Percentages of body fat were not different statistically among all the group pre and post-test. There were no significant time-group interaction ($df=3$, $F=2.40$, $p=0.081$) in percentage of body fat. However, there was a significant decrease of body fat percent by -4.5% in OJ group ($p=0.03$).

Fig. 2 illustrates that participants' predicted VO_{2max} were similar in all the groups at pre-test. A significant time-group interaction ($df=3$, $F=3.89$, $p=0.017$) in predicted VO_{2max} was observed. Furthermore, the predicted VO_{2max} values in J ($p=0.015$) and OJ ($p=0.002$) groups were found to be increased significantly compared to their respective pre-test value. The percent increase of predicted VO_{2max} value in OJ group was the highest (+8.4%) among the groups. The percent change in other groups was J: +6.2%, O: -0.5%, and C: -2.6% respectively.

The results of lipid profile can be seen in **Fig. 3, 4, 5** and **6**. **Fig. 3** shows the results of serum TC. It was found that there were no significant differences of serum TC concentration among the groups at baseline. There was no significant time-group interaction ($df=3$, $F=0.756$, $p=0.526$) in serum TC. However, further analysis showed that serum TC concentration in O group ($p=0.001$) and J group ($p=0.015$) decreased significantly compared to their respective pre-test value, while OJ group ($p=0.081$) exhibited a tendency for a significant decrease compared to the respective pre-test value. The percent decrease of serum TC concentration in O group was the highest (-9.4%) among the groups. The percent change in other groups was J: -6.8%, OJ: -5.7%, and C: -4.2% respectively.

As illustrated in **Fig. 4**, serum HDL-C concentration were similar in all the groups at pre-test. Even though no significant time-group interaction ($df=3$, $F=1.00$, $p=0.401$) in serum HDL-C was found, further analysis showed that serum HDL-C concentration in OJ group increased significantly ($p=0.011$) compared to pre-test value. The percent increase of serum HDL-C in OJ group was the highest (+10.2%) among the groups. The percent changes in other groups was C: +8.0%, J: +4.9%, and O: +0.7% respectively.

Fig. 5 shows the results of serum TG. There were no significant differences of TG concentration observed among all the groups at pre-test. Results indicated that there was significant time-group interaction ($df=3$, $F=3.67$, $p=0.02$) in serum TG. In addition, serum TG concentration in OJ group decreased significantly ($p=0.003$) compared to pre-test value. The percent decrease of serum TG in OJ group was the highest (-26.8%) among the groups. The percent change in other groups was J: -17.5%, C: -7.2%, and O: +15.0% respectively.

In **Fig. 6**, there were no significant differences of LDL-C concentration among all the groups at pre-test. It was found that there was a significant time-group interaction ($df=3$, $F=2.91$, $p=0.046$) in serum LDL-C. Further analysis showed that serum LDL-C concentration in O group ($p<0.001$), J group ($p<0.001$) and OJ group ($p=0.022$) decreased significantly compared to their respective pre-test value. The percent decrease of serum LDL-C concentration in O group was the highest (-18.7%) among the groups. The percent change in other groups was J: -12.0%, OJ: -9.2%, and C: -7.2% respectively.

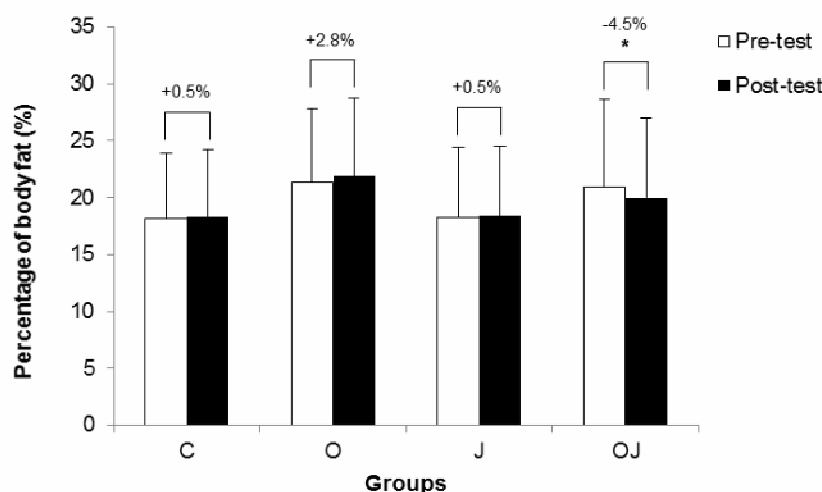


Fig. 1. Means percentage of body fat at pre- and post-test

Abbreviations: C, control group; O, oat bran supplementation alone group; J, jogging exercise alone group; OJ, combined oat bran supplementation and jogging exercise group.

* significantly different from pre-test ($p<0.05$)

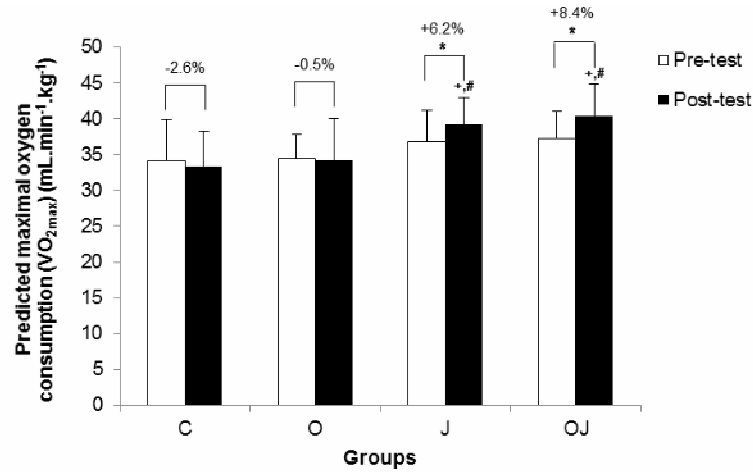


Fig. 2. Means predicted maximal oxygen consumption (VO_{2max}) at pre- and post-tests

Abbreviations: C, control group; O, oat bran supplementation alone group; J, jogging exercise alone group; OJ, combined oat bran supplementation and jogging exercise group.

* significantly different from pre-test (p<0.05)

+ significantly different from respective C group at post-test (p<0.05)

significantly different from respective O group at post-test (p<0.05)

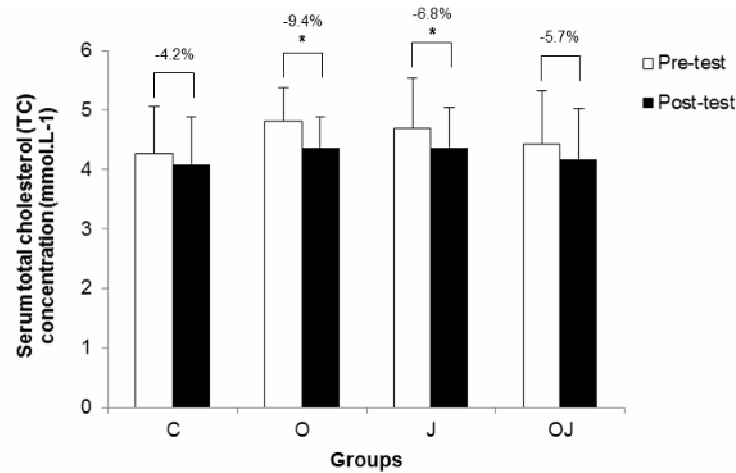


Fig. 3. Means total cholesterol (TC) concentration at pre- and post-tests

Abbreviations: C, control group; O, oat bran supplementation alone group; J, jogging exercise alone group; OJ, combined oat bran supplementation and jogging exercise group.

* significantly different from pre-test (p<0.05)

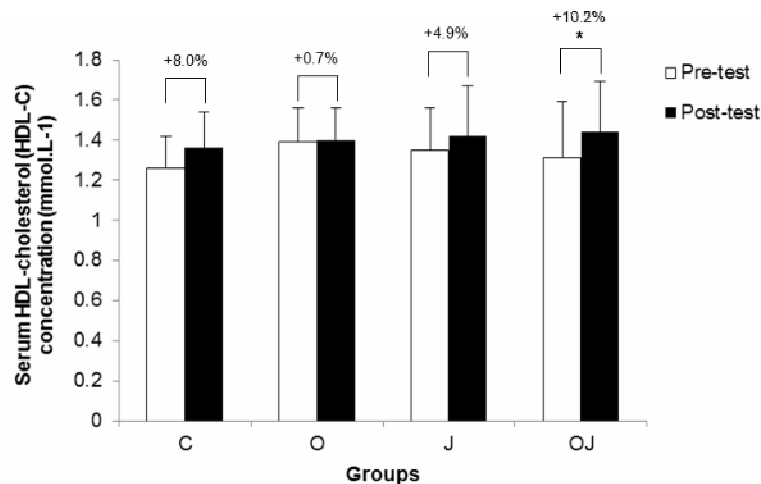


Fig. 4. Means HDL-cholesterol (HDL-C) at pre- and post-tests

Abbreviations: C, control group; O, oat bran supplementation alone group; J, jogging exercise alone group; OJ, combined oat bran supplementation and jogging exercise group.

* significantly different from pre-test (p<0.05)

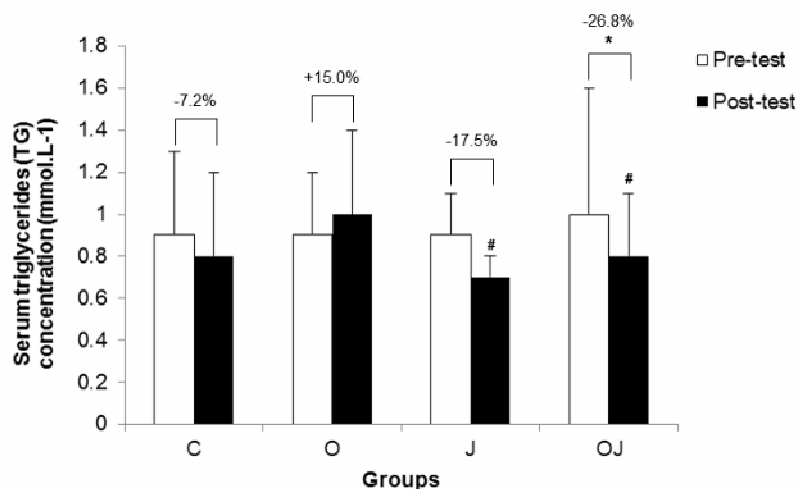


Fig. 5. Means triglycerides (TG) concentration at pre- and post-tests

Abbreviations: C, control group; O, oat bran supplementation alone group; J, jogging exercise alone group; OJ, combined oat bran supplementation and jogging exercise group.

* significantly different from pre-test ($p < 0.05$)

significantly different from respective O group at post-test ($p < 0.05$)

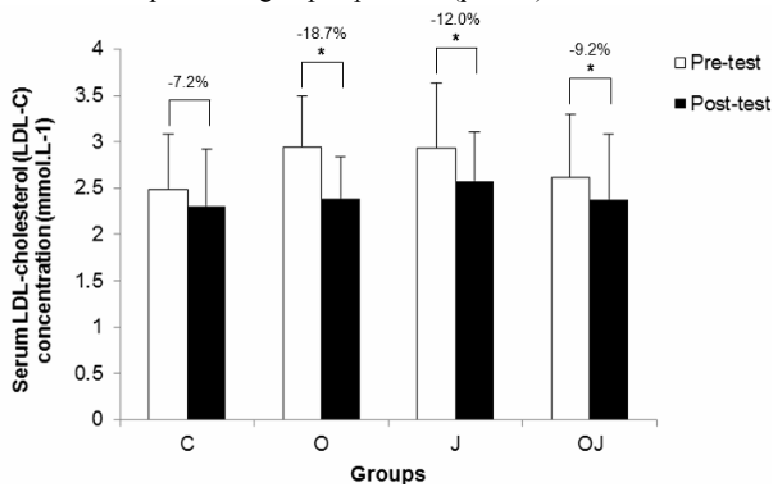


Fig. 6. Means LDL-cholesterol (LDL-C) concentration at pre- and post-tests.

Abbreviations: C, control group; O, oat bran supplementation alone group; J, jogging exercise alone group; OJ, combined oat bran supplementation and jogging exercise group.

* significantly different from pre-test ($p < 0.05$)

Table 1. Means superoxide dismutase (SOD) and glutathione peroxidase (GPx) activity at pre- and post-tests

Groups	SOD (U.mL ⁻¹)			GPx (U.L ⁻¹)		
	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Percent change compared to pre-test (%)	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Percent change compared to pre-test (%)
C	2.23 ± 1.57	1.74 ± 0.93	-21.8	60.52 ± 8.20	60.03 ± 10.12	-0.8
O	2.14 ± 0.90	3.97 ± 2.14* ⁺	+85.5	59.29 ± 8.51	47.34 ± 23.32*	-20.2
J	1.05 ± 0.32* [#]	1.77 ± 0.86 [#]	+68.6	61.64 ± 11.06	68.10 ± 10.13 [#]	+10.5
OJ	1.47 ± 0.47	2.68 ± 1.12* [#]	+82.3	60.96 ± 9.45	66.25 ± 9.90 [#]	+8.7

Abbreviations: C, control group; O, oat bran supplementation alone group; J, jogging exercise alone group; OJ, combined oat bran supplementation and jogging exercise group.

* significantly different from pre-test ($p < 0.05$)

⁺ significantly different from respective C group ($p < 0.05$)

[#] significantly different from respective O group ($p < 0.05$)

Table 1 tabulates the means serum SOD and GPx activity at pre- and post-tests. At pre-test, SOD activity in J group was significantly lower than C group ($p = 0.013$) and O group ($p = 0.011$). Time-group interaction was statistically significant borderline ($df = 3, F = 2.777, p = 0.058$) in SOD activity. Further analysis showed that serum

SOD activity in O group ($p=0.001$) and OJ ($p=0.021$) groups increased significantly compared to their respective pre-test value. The percent increase of serum SOD activity in O group was the highest (+85.5%) among the groups. The percent change in other groups was OJ: +82.3%, J: +68.6%, and C: -21.8% respectively.

There were no significant differences in serum GPx activity among the groups at pre-test. Analysis results showed that there was no significant time-group interaction ($df=3$, $F=2.45$, $p=0.083$) in serum GPx activity. However, further analysis showed that serum GPx activity in O group ($p=0.042$) decreased significantly compared to pre-test value. The percent decrease of serum GPx activity in O group was the highest (-20.2%) among the groups. The percent change in other groups was J: +10.5%, OJ: +8.7% and C: -0.8% respectively

Discussion

In the present study, the participants were aged and weight-matched and then randomly assigned into four different groups before the commencement of the study in order to reduce the effects of confounding variables among the groups and pre and post-intervention. There were no significant differences in body weight, height, body mass index (BMI) and percentage of body fat among all the four groups at the beginning of the study.

After 8 weeks of experimental period, the present study also found that there were no significant differences in body weight pre and post-tests in all of the groups. The present observation that oat bran supplementation alone did not affect body weight was in agreement with Spencer et al. (1991) and Stern et al. (1992). Beck et al. (2010) have found that 3 months of chronic consumption of diet with 5 g moderate and 8 g high β -glucan did not significantly affect body weight and body fat. Rebello et al. (2016) mentioned that oat products which are high in dietary fibre and protein can increase satiety and suppress hunger for a long period of time in a day, this may reduce daily calorie intake of an individual and subsequently affecting body weight. Several other epidemiological studies also reported that body fat and BMI were negatively associated with daily fibre intake (Kromhout et al., 2001; Nelson & Tucker, 1996). The observation of the present study with absence of significant changes in body weight and body fat in oat bran alone group may reflect that the duration of the present study may be not long enough to elicit positive response from oat bran consumption alone on body weight and body fat.

Kromhout et al. (2001) observed that physical activity was negatively associated with BMI and body fat, and suggested that regular exercise could decrease body weight and body fat significantly. Meanwhile, it was reported that moderate intensity exercise is more effective in increasing fat oxidation and burns more body fat than high intensity exercise does (Achten & Jeukendrup, 2004; Romijn et al., 1993; Rosenkilde et al., 2012). However, our findings showed that jogging exercise with moderate exercise intensity at 55% to 70% of age-predicted HR_{max} , 30 minutes per day, and 3 days per week for 8 weeks in J group did not affect the body weight and body fat. Rosenkilde et al. (2012) and Romijn et al. (1993) mentioned that increasing the dose of exercise or intensity is not always effective to lose weight and body fat. Even though estimated calorie burn during exercise was approximately 4 104 cal, which correspond to 456 g of body fat during the 8 weeks of study period, the observation of jogging exercise alone did not affect body fat in the present study might be due to prescribed exercise or duration of the present study was not long enough. Unfortunately, dietary intake of all the participants was not recorded and it is likely that the dietary intake of the participants in the present study may have contributed to the observation of the present study. Hence, it may be regarded as a limitation in our study as it might act as a confounder factor upon the body weight changes.

On the other hand, the present findings showed that combining oat bran supplement with jogging exercise was effective to optimise body composition by reducing percentage of body fat significantly by -4.5%. This result implied that maybe the oat bran supplementation can further help to reduce body fat when combined with jogging exercise in OJ, compared to J alone.

Consistent with our finding, Hill et al. (2007) also reported that combined fish oil supplementation with regular walking exercise significantly reduced body fat compared to fish oil supplementation alone. Inconsistent to the present study, the absence of positive effects of combined chocolate malt drink consumption and aerobic dance exercise on body weight and body fat in young females were reported by Wadih et al. (2015). The discrepancy between Wadih et al. (2015) and the present study showed that different combination of nutritional supplementation and type of exercise may elicit different results on body composition.

The exercise intensity prescribed in the present study was considered moderate based on the observation that the post exercise heart rate of the participants ranged from 110 bpm to 40 bpm which represented 55% to 70% of age-predicted HR_{max} . The significant increase of aerobic capacity in J and OJ groups showed that the prescribed exercise intensity and duration of 30 minutes per day, 3 times per week for 8 weeks in the present study was adequate for improving aerobic capacity of the participants. The present beneficial effect of exercise alone on aerobic capacity was in agreement with several other previous studies (Fisher et al., 2015; Kemmler et al., 2004; Suter et al., 1994). Fisher et al. (2015) reported that moderate intensity exercise is more effective to improve cardiovascular fitness than high intensity training. In the present study, the beneficial effects observed in OJ and J groups on aerobic capacity, but not O group, implying that regular aerobic exercise such as jogging was effective on enhancing cardiovascular fitness compared to nutritional supplementation.

The main finding of the present study was that OJ group effectively decreases in TG and LDL-C, and increases HDL-C, while oat bran supplementation or jogging exercise alone were only able to reduce TC and LDL-C levels. It is known that both oat bran consumption alone and jogging exercise alone have cholesterol-lowering effects potentially.

The present findings have elicited a synergistic or additional effect on lipid profile as more parameters of lipid profile were improved compared to O and J groups. In a previous study by Berg et al. (2003), it was observed that combined oat bran enriched-diet with physical activities such as gymnastics, endurance training and leisure time activities could also improve TC, TG and LDL-C levels in a patient with coronary heart disease risk. Although our study did not find any significant combined effect of oat bran supplementation and jogging exercise on TC, there was a 5.7% reduction in TC after the intervention. Serum TC is contributed by LDL-C, VLDL-C and HDL-C. Although LDL-C is the major contributor of TC, i.e. 60-70% of TC, it should be noted that HDL contains 20-30% of TC (NCEP ATP III, 2002; Tortora & Derrickson, 2009). Therefore, a lack of difference in TC between pre-test and post-test in the present study may be explained by an increase in HDL-C after intervention in the combined group. Nevertheless, it can be speculated that a combination of exercise and nutritional factors is important in upregulating the HDL-C level.

Stern et al. (1992) reported that oat bran supplementation alone reduces both TC and LDL-C levels and the authors speculated that the cholesterol-lowering effect was mainly due to the high soluble fibre content in oat bran namely β -glucan. It was also proven that the reduction of TC and LDL-C levels following soluble fibre consumption were significantly associated with the loss of bile acids through faeces, which implied that soluble fibre consumption may affect bile acids regulation (Jenkins et al., 1993). The speculated mechanism was that the viscous property of β -glucan could interfere with the dietary fat and cholesterol absorption within the gastrointestinal tract, affecting recirculation of cholesterol and bile acids, and LDL-cholesterol was used to compensate for the loss of hepatic pool of cholesterol afterwards in order to synthesize new bile acid (Ellegård & Andersson, 2007). Another proposed mechanism pointed out that fermentation products of short-chain fatty acids (SCFAs) from soluble fibres such as acetate, butyrate and propionate inhibit the synthesis of hepatic cholesterol (Hara et al., 1999). The improvements in lipid profile levels following oat bran supplementation as in the O and OJ group in our study can be supported by the above phenomenon.

It was demonstrated that exercise especially at low and moderate intensity can enhance lipid utilisation and therefore reduce plasma lipid levels (Mann et al., 2014; Romijn et al., 1993). Our findings showed that a pronounced decrease of TG levels in both exercise groups of J (-17.5%) and OJ (-26.8%). The reduction in TG can probably be attributed to the jogging exercise programme. It is possible that the fatty acids released from the hydrolysis of TG in VLDL were used by the muscle as fuel during exercise. Morio et al. (2004) demonstrated that VLDL-TG turnover was increased during and after moderate-intensity exercise in young sedentary subjects. Our findings were also consistent with previous studies which find that exercise alone could significantly reduce TC and LDL-C levels (Berg et al., 2003; Heath et al., 1983; Kannan et al., 2014). Heath et al. (1983) also found that moderate intensity exercise for 6 months could not only improve TC and LDL-C levels, but also TG and HDL-C levels in a patients with coronary artery disease. Meanwhile, Kannan et al. (2014) found that 15 weeks of moderate intensity cycling significantly improved TC, TG, LDL-C and HDL-C levels in obese adults. It was believed that the extensive improvement of lipid profile in these previous studies were due to the long period of intervention study.

The present study also found that there were significant increases of SOD activity in the O and OJ groups following the intervention. The percent change of SOD was highest in the O group (+85.5%). However, a significant decreases of GPx activity was also observed in this group with the highest percent change (-20.2%). The observed increased trends of SOD and GPx activity in the combined OJ group were in agreement with Wadiah et al. (2015), who reported that activities of these two enzymes were increased following combined chocolate malt drink consumption with aerobic dance exercise for 8 weeks. The increase of SOD in the OJ group was higher compared to the J group and this finding was similar to Damirchi et al. (2015), who reported that the combined aerobic with garlic supplementation group had a higher increase of SOD than the aerobic alone group. However, synergistic effect of oat bran and jogging exercise was not demonstrated in the OJ group as the observed SOD and GPx response in the OJ group was apparently similar to the J group.

In our study, the increased trends of SOD and GPx levels without statistical significance were observed in the J group. Regular exercise has been shown to elicit higher oxidative stress than sedentary individuals (Goon et al., 2009). The response to increased oxidative stress is associated with the upregulation of the various antioxidant activities in the body including the endogeneous antioxidant enzymes such as SOD, GPx and CAT (Cheeseman & Slater, 1993). Even though we did not measure oxidative stress levels, the increased trend in SOD and GPx in the J group in this study reflects that there might be an increase in oxidative stress following regular jogging exercise for 8 weeks (Goon et al., 2009; Huang et al., 2014). It has also been shown that both high intensity and endurance training upregulate antioxidant enzyme activities in response to chronic exposure to oxidants during regular exercise training (Criswell et al., 1993; Powers et al., 1999).

Oxidative stress is attenuated by an elaborate antioxidant system comprising of enzymatic antioxidants and non-enzymatic antioxidants such as Vitamin A, C, E, SOD, GPx, GSH and flavonoids (Kanter, 1998;

Powers et al., 2004). Both SOD and GPx play a different role in ameliorating oxidative stress in the human body. SOD and catalase (CAT) provide a primary defence against superoxide radicals when they dismutase superoxide radicals (O_2^-) into hydrogen peroxide (H_2O_2) or oxygen (O_2) (Fridovich, 1995; Kellogg, 1975; S K Powers et al., 1999; Yu, 1994). Superoxide (O_2^-) is produced by phagocytes to kill pathogens, and as a by-product of mitochondrial respiration and xanthine dehydrogenase (Kellogg, 1975; Turrens, 2003). H_2O_2 by itself is an oxidising agent too but not particularly reactive and it can be readily removed from cells by the action of antioxidant enzyme such as and GPx (Cheeseman & Slater, 1993). H_2O_2 is then further catalysed by GPx and reduced to water (H_2O), using reduced glutathione (GSH) as the electron donor (Ji, 1995; Powers & Hamilton, 1999). With the increased SOD in the O, J and OJ groups, it can be interpreted that more superoxide ions was produced and catalysed into H_2O_2 . In response to the high level of H_2O_2 , GPx is expected to increase as well to eliminate H_2O_2 . However, only a small non-significant increase in GPx was observed in the J and OJ groups, while a significant decreased of GPx was observed in the O group.

Additional exogenous antioxidant supplementation can attenuate enzymatic antioxidants. For example, Morrison et al. (2015) reported that supplementation of Vitamin C and E attenuated SOD and GPx activity while Abd Hamid et al. (2011) reported that supplementation of Vitamin E attenuated SOD activity only. The underlying mechanism for these situations is unclear but it was speculated that these vitamins can take over the role of eliminating free radicals and give negative feedback on gene expression of SOD and GPx enzymes. Subsequently, SOD and/or GPx activities may attenuated (Abd Hamid et al., 2011; Buettner & Jurkiewicz, 1996; Morrison et al., 2015). The precise contribution of oat bran supplementation to the overall antioxidant status in a sedentary group with oat bran supplementation is still unclear. Several previous phytochemical studies revealed that oat bran possesses highest avenanthramides compared to other oat morphological parts (Dimburg et al., 1993; Serea & Barna, 2011). Avenanthramides are phenolic compounds which have been proven to possess anti-atherogenic (Chen et al., 2004; Liu et al., 2004) and antioxidant properties (Leopoldini et al., 2011).

However, the postulated antioxidant compounds from oat bran did not induce a similar effect as antioxidant vitamins (Abd Hamid et al., 2011; Buettner & Jurkiewicz, 1996; Morrison et al., 2015) to attenuate antioxidant enzymes in the O and OJ groups. Feng et al. (2013) have demonstrated that human dermal fibroblast which was pre-incubated with oat bran in *in vitro* study and later being exposed to oxidative stress injury from hydrogen peroxide, and the outcomes showed that the activities of antioxidant enzymes i.e. SOD and GPx were still observed to increase. Similarly, administration of avenanthramides from oat bran extracts upregulated SOD and GPx in D-galactose-induced oxidative-stressed mice (Ren et al., 2011) and acute consumption of avenanthramides in humans also raised GPx level by 30-34% (Chen et al., 2007). Based on this evidence, it is assumed that oat bran supplementation induces response in antioxidant enzymes regardless of their readily available content of phenolic substances. Even though both antioxidant vitamins and phenolic avenanthramides are endogenous antioxidants, each of them might have different antioxidant mechanisms, and thus the response will not be similar. These findings (Chen et al., 2007; Feng et al., 2013; Ren et al., 2011) were in agreement with our finding that the SOD level was increased significantly following oat bran supplementation in the O and OJ groups. However, GPx response in the O group was rather unexpected. These findings could be attributed to the different types of antioxidant compounds or antioxidant reactions from the oat bran supplementation. Thus, the precise mechanism on how oat bran upregulated SOD activity and downregulated GPx activity in the present study is still unknown and needs to be explored further.

The present finding of exercise alone indicated a trend of increased SOD and GPx levels compared to the pre-test value. These findings were in agreement with several previous studies (Goon et al., 2009; Huang et al., 2014; Onur et al., 2011; Wadiah et al., 2015). Huang et al. (2014) reported that there was no significant change in GPx level at week 8 but there was a significant increase in GPx activity at week 12. Similarly, Goon et al. (2009) reported that there was no significant increase in SOD level at month 6 but there was a significant increase in SOD activity at month 12. These results indicated that the upregulation of GPx and SOD activity may require a longer duration before it is significantly observable. Thus, it is possible that the increasing trend in the measured SOD and GPx might reflect that in the current study, the response of enzymes towards exercise was at an early phase, and a longer duration of experimental study may be needed to observe full adaptation of antioxidant enzymes towards regular exercise alone.

Conclusions

In conclusion, 18 g of oat bran supplementation alone, daily for 8 weeks, was effective in reducing both TC and LDL-C levels, and increasing superoxide dismutase level while jogging exercise alone for 30 minutes per session, 3 times per week for 8 weeks could improve aerobic capacity and reduce TC and LDL-C. Furthermore, when oat bran supplementation was combined with jogging exercise for 8 weeks, more beneficial effects were observed. These include improved aerobic capacity, decreased body fat percent, TG and LDL-C, increased HDL-C levels and increased superoxide dismutase level. Therefore, combined oat bran supplementation with jogging exercise can be recommended as a guideline in planning exercise and nutritional programmes for young male population.

Conflicts of interest - The authors declare that there is no conflict of interests regarding the publication of this paper.

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