BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, June 2017. Vol. **14**(2), p. 785-792

The Effects of Moderate-Intensity Aerobic Activity Before and After Training on Acquisition and Consolidation Memory In Short Service Badminton

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http://dx.doi.org/10.13005/bbra/2509

(Received: 17 May 2017; accepted: 30 May 2017)

Acquisition and consolidation of motor skills is important in learning. Thus, aerobic activity can be a necessity at the time of acquisition of motor skills. This study aims to investigate the impact of moderate-intensity aerobic activity before training on acquisition and consolidation of memory for the short service in badminton. In this quasi-experimental study, 38 participants aged 17 to 19 years were selected by Convenience Sampling and Purposive Sampling. Participants were randomly assigned to two experimental groups (n =14 and 10) and a control group (n = 14) based on the aerobic capacity. Before and after the badminton short service training, the participants ran for 20 minutes on a treadmill at a speed of about 70 percent of maximum heart rate. In various stages of training, the precision of ball landing spots was measured based on the French test at the time of acquisition, immediate retention, retention and transfer in all three groups. The repeated measures ANOVA were used to compare between-groups mean and within-groups mean. The results were analyzed at the significance level of $p<0.05$. There was no significant difference between groups in terms of the accuracy of the short service in badminton in the French test based on aerobic exercise before and after training ($p<0.05$).A significant difference was observed between all parts of the test and the transfer test ($p>0.05$). According to the impact of moderate-intensity aerobic activity before and after training on the acquisition and consolidation of memory, there was no significant difference in the accuracy of the short service in badminton.

Keywords: Aerobic activity, Acquisition, Consolidation memory, Short service badminton.

Motor learning is a set of processes associated with the practices and experiences leading to relatively constant changes in the ability of carrying out movements. A process is a series of events that gather together and lead to the results, states or certain changes (Schmidt & Lee, 1988). One of the main objectives of the study of the cognitive learning is dependent variables that enhance or disrupt the learning and may play no role in it. Thus, it is necessary to identify these variables related to learning and practical applications in training and other learning opportunities (Schmidt & Lee, 1988).

In this regard, the researchers of motor learning sought to examine the factors that enhance the performance of motor skills over time. One of the factors that affect the formation of memory and motor learning is practicing skills with physical activity (Brisswalter, Collardeau, & René, 2002; Lucas, *et al*., 2012; McMorris, Sproule, Turner, & Hale, 2011). Participating in physical activities such as aerobic exercises can be particularly affect the formation of memory and motor learning (Phillip D Tomporowski, 2003). In this context, participation in regular physical activity can be considered as one of the best solutions available for learning and memory (Cotman, & Christie, 2007). The results show that the potential impact of intense exercise on identifying and encoding procedural

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information during exercise after the training is not transmitted immediately and is not observed at the time of acquisition. Hence, it can be useful to implement a period of intense exercise related to motor tasks that focus on accuracy and acquisition of motor skills (McMorris, *et al*., 2011). In fact, recent evidence suggests that moderate intensity exercise has harmful effects on the accuracy (McMorris, *et al*., 2011). Therefore, the high arousal level enhances the process of encoding that temporarily inhibits data recovery through memory consolidation (Walker, 1958). This process has destructive effects on short-term memory (Cian & Raphel, 2001). Another possibility is that the memory representation of motion is still not stabilized when the first retention test is run. Therefore, the positive impact of intense exercise on memory is not yet fully proven, and there is a contradiction between immediate and delayed retention tests which is not unusual in studies of learning motor skills (Kantak & Winstein, 2012).

The position of aerobic exercise in training program is one of the things that little research has been done on it. Other research has examined the effect of aerobic exercise intervention on the short serve in badminton using the cognitive task (McMorris, *et al*., 2011; Phillip D Tomporowski, *et al*., 2005) or the tracking task (Roig, , 2012) and the continuous task. They have shown different results on the effect of aerobic exercise on motor tasks. In this context, Labban *et al*. (2011) reported that performing aerobic exercises before training can be more effective than exercise after training. In contrast, Roig *et al*. (2012) examined the effect of moderate-intensity aerobic exercises on elbow torque. They concluded that the there is no short-term effect of aerobic exercise and the improved performance can be seen only in the delayed retention. They used the tracking task for the visual-motor accuracy. Thus, a lever was used to show torque and angle changes and track the target on the screen from left to right. Findings of this study showed no significant effect, but they indicated improvement in accuracy of the visual-motor task over time. Other studies have shown that aerobic exercise improves the delayed retention in motor skills. These findings were approved for adolescents (9.5 years), middle-aged people (19-25 years) and elderly people (60-74 years) (Hillman, *et al*., 2009; Kamijo, *et al*., 2009). A study investigated the impact of aerobic activities on the cognitive performance through the comparison of two methods of cycling and running on a treadmill. The findings indicated that aerobic exercises by cycling enhance performance during and after exercise, but aerobic exercises by treadmill cause disturbance during exercise and have little improvement in performance after exercise. The results indicated a complex relationship between exercise and cognitive performance and the increased performance depends on the type of cognitive skills and the type of exercise(Lambourne & Tomporowski, 2010). Considering the fact that the implementation of aerobic exercise can be effective in the learning and acquisition process and given that training new skills in athletes is tastefully done in terms of primacy and recency of the training time for aerobic activities such as the warm-up. Some of the trainers perform the training at the beginning of the training session; some others do it after the warm-up and aerobic activities and even at the end of the training session. Therefore, the question arises that what impact cans moderate-intensity aerobic activity, such as warm-up before or after a skills training session, have on the learning process?

MATERIALS AND METHODS

Subjects

Participants

The study was an applied research based on the quasi-experimental design. Thus, two experimental groups and one control group were compared. The sample included 38 male students aged between 19 and 17 years and lived in the city of Mashhad. In the first step, the participants were acquainted with the nature and the process of the study. Inclusion criteria were as follows: being healthy based on health questionnaire, lack of using drugs, no smoking and lack of familiarity with the badminton skills. Participants were voluntarily participated in the study and signed a consent form. Participants were randomly assigned to two experimental groups (n =14 and 10) and a control group (n = 14) based on the results of Bruce and Raven IQ test. The body mass index was in the range of 21.30 ± 2.55; the intelligence was in the range of 115.24 ± 9.67; and maximal oxygen uptake was in the range of 44.90 ± 7.05 mL / kg per minute.

Instruments and Equipment

Height of participants was measured by the digital Stadio meter Seca (made in Germany), with a sensitivity of 5 mm, to calculate Body Mass Index (BMI).Thus, the participants did not eat or drink for four hours before the test and possibly their bladder, and stomach and intestine were discharged. The participants' IQ was measured by the Raven IQ test. Raven IQ test included 60 image questions (A12, B12, C12, D12, E12) and each question had 6 to 8 options. Finally, scores of 60 questions were calculated to measure IQ. The correlation coefficient of the test was measured by Stanford and Wechsler tests (0.4-0.75)and the validity was 0.7 – 0.9 at older ages (Wilson, *et al*., 2009).

Maximal oxygen uptake was one of the inclusion criteria

It was measured by Bruce Test. In this 10-step method, the treadmill was started at 2.74 km/hr (1.7 mph) and at a gradient (or incline) of 10%. Speed and incline progressively increased until the participant was exhausted and not able to run test. Maximal oxygen uptake in Bruce Test was calculated using Equation 1.

Maximal oxygen uptake (ml/kg/min) = 14.8 – (1.379 × T) + (0.451×T2) – (0.012×T3)

French badminton test was used to measure score of the short serve (Panahi Broujeni, Shojaei, & Daneshfar, 2014). This test evaluates the accuracy of the short serve in badminton with respect to the ball landing in the confluence of the length line and the short service line. Qulysis motion analysis system made by Qualisys AB, 2013-12-12 was used to measure the actual landing distance from the point and a phosphorus marker with the width of 5 mm was installed on the perimeter of shuttle ball. Yonex rackets and balls approved by Ball Badminton Federation and a net with a height of 1.55 meters and a length of6.10 meters were used for the short serve in badminton.

Methods

Each of the groups participated in an initial training session, including how to hold a racket correctly, familiarity with the court, ball and rally. Each group should be scheduled for the following stages of training, acquisition, immediate retention, retention and transfer. All activities of the groups were done in the morning in order that there is no difference in runtime. In the first session, Beck India Short Service in badminton was trained for all the participants. The four blocks of 10 trials were conducted by specifying the ball landing area based on the French test in badminton. There was 5-secondrest between each trial and 5-minute rest between each block (Panahi Broujeni, *et al*., 2014). The participants was given the same description and feedback during each step. The control group did not take any action before and after training and trials. The experimental group 1 (n = 14) before training and the experimental group 2 (n = 10) after 40 trials ran an on a treadmill for 20 minutes. The first and last 3 minutes was under the lower pressure for the warm-up and warm-down. They ran for 14 minutes at 65% of maximal oxygen consumption. The second session (continuation of the process of acquisition and acquisition test) was held for each group after 48 hours. Again, the participants performed four blocks of 10 trials (without any aerobic activity).At the end of 40 trials in the second session, each participant rested for 40 minutes and then each participant performed 10 trials to review the immediate retention. The third session was held for each group after 72 hours. Again, the participants performed 10 trials. The fourth session was held for each group after 96 hours. Again, the participants performed 10 trials as before. They performed 10 trials by changing the ball landing area to check the transfer. Before performing the trials, all the groups performed the same stretching and flexibility exercises for 5 minutes. The data were collected based on lining

Table 1. Participant characteristics at baseline

Groups	Variations (M±SD)				
	Age (years)	Height (m)	Weight (kg)	Body Mass Index (kg/m2)	Raven IQ Test
Experimental 1	17.67±0.52	175.30±3.56	63.50±7.55	44.36±6.82	112.93±11.06
Experimental 2	17.80±0.45	173.83±5.84	66.58±14.13	44.90±7.85	115.20±8.31
Control	17.5±0.58	174.00±6.78	66.31±10.63	43.57±7.67	119.46±5.87

the badminton court and the French test on the ball landing area. The scores were recorded using the Qulysis motion analysis system.

Statistical methods

The collected data were analyzed using SPSS (version 16). After confirmation of normal distribution of the data using the Kolmogorov-Smirnov test (K-S) and homogeneity of variance using Levene's test, the repeated measures ANOVA was used to compare between-groups mean and within-groups mean. The results were analyzed at the significance level of $p<0.05$.

RESULTS

Table 1 shows the characteristics of the participant in the study for both control and experimental groups. There was no significant difference between three groups before the intervention in terms of age, height, weight and IQ test and maximal oxygen consumption ($p>0.05$).

Table 2 shows the results of the ball landing area to the confluence of the long line and short line in badminton court in millimeters for three groups. According to French Short Serve Test, the lower the distance of the ball landing to the point, the higher the accuracy will be. According to Table 3, there is no significant difference in the effect of aerobic activity before and after the short serve training at all stages of acquisition ($p = 0.563$) and the effect of memory consolidation on the accuracy of the short serve ($p>0.05$). The results of Table 4 shows that repeating the serve has a significant effect on the accuracy of the short serve in badminton ($P=0.001$, $F= 4.920$). According to the results of the least significant difference (LSD) test, there is a significant difference between pre-test and other steps. There was no significant difference between the various methods (aerobic activity before and after training) ($P= 0.426$, $F= 0.875$).The number of repeats at different times had no significant effect on different methods ($P= 0.097$, $F= 0.999$).

DISCUSSION

This study aimed to investigate the impact of moderate-intensity aerobic activity before training on acquisition and consolidation of memory for the short service in badminton.

Table 2. Measurement accuracy of short service badminton in the five stage test in three groups

Groups	Different stage test (M±SD)				
	The accuracy of short service badminton (Pretest)	The accuracy of short service badminton (Acquisition phase)	The accuracy of short service badminton (Immediate retention phase)	The accuracy of short service badminton (Remember phase after next 5 days)	The accuracy of short service badminton (Remember phase after next 9 ays)
Experimental 1 (Activities before education)	835.491±225.74	694.459±216.30	707.646±166.30	720.701±226.67	687.397±196.73
Experimental 2 (Activities after education)	800.502±263.89	676.024±170.79	722.365±124.49	690.446±134.42	700.950±107.53
Control	752.387±187.49	622.527±147.21	662.089±182.98	656.672±154.07	645.012±137.27

The ball landing area to the confluence of the long line and short line in badminton court in millimeters

Table 3. Comparison of within group variance and between group of accuracy of short service badminton in separate groups during test

Stages	Variations	Sum squares	df	Mean Square	F	*P*-value
Pretest	1	48661.156	2	24330.578	0.488	0.618
	2	1746301.9	35	49894.339		
Acquisition phase	1	38484.974	2	19242.487	0.584	0.563
	2	1152535.3	35	32929.58		
Immediate retention phase	1	24888.469	2	12444.235	0.466	0.631
	2	934299.48	35	26694.271		
Remember phase after next 5 days	1	28720.873	2	14360.436	0.441	0.647
	2	1139204.7	35	32548.705		
Remember phase after next 9 days	1	21471.542	2	10735.771	0.441	0.647
	2	852237.78	35	24349.651		

The results of the study indicated that the aerobic exercise has no significant effect on the accuracy of acquisition and retention of the short serve in badminton. The findings indicated that aerobic exercise after training can lead to a drop in the accuracy of the immediate retention. These results were consistent with findings of the studies conducted by Roig *et al*. (2012) and Cian *et al*. (2001). Roig *et al*. (2012) reported that moderate-intensity aerobic exercise does not have a significant effect on the performance of the tracking task. These results were inconsistent with findings of the studies indicating that aerobic exercise has a positive effect on the acquisition of the accuracy of motor skills (Sjöberg, 1980; Phillip D Tomporowski, Ellis, & Stephens, 1987; Winter, *et al*., 2007).

According to the findings, the difference in the accuracy of the serve in the pre-test of both groups reflected the effect of aerobic exercise before training on the accuracy of the serve. Although a 35 mm difference in accuracy of the serve between the two groups was not statistically significant, it could show important differences. This difference was probably the result of aerobic exercise in the experimental group1 and showed an increase in the accuracy. In the pre-test, the significant improvement was created in the aerobic exercise before and after training and without aerobic exercise (control group). This improvement could not be due to aerobic exercise because two experimental groups and, in particular the control group did not do any exercise before acquisition. However, learning could significantly occur in the pre-test in a way that errors were greatly reduced. According to the analysis of the steps of learning, the research samples in the pre-test were in the step of the cognitive learning. Therefore, the significant improvements occurred in the pre-test. However, the research results were inconsistent with other findings in this regard. For example, Dietrich (2004) reported that aerobic exercise can be harmful for the motor function (Dietrich & Sparling, 2004). Some research considered these exercises useful for the motor function (Pesce, 2003) and some studies reported no effect (Philip D Tomporowski, 2008). Also, Labban *et al*. (2011) reported that aerobic exercises before training can be more effective than aerobic exercises after training; our findings support this interpretation. Roig *et al*. (2012) achieved the opposite findings. They conducted a study and concluded that in the early stages of learning, there is no significant difference but after seven days participating in the retention tests, performing aerobic exercises after training has a greater effect on the learning before the training.

By comparing the experimental groups with the control group, we conclude that the highest error in the test of acquisition and retention of three groups is related to the errors in the 5 days after the intervention in the experimental group 1, as well as immediate retention in the experimental group 2 after 40 trials. Therefore, performing the intensity aerobic exercises before training at 65% to 70% of maximal oxygen consumption is more effective in the performance and stabilizes memory. Memory consolidation for 5 days can create deep and durable learning and then motor memory loss occurs. It is not clear why these exercises have a significant impact on the acquisition and the immediate retention. In this case, the aerobic exercise can improve the accuracy of serve up to 9 days, but the progress is very slow. Given that minor differences in the levels of performance make much difference in the result of the race, this progress should be considered. The results of the experimental group 2 also support this explanation. When the aerobic exercise is performed after training, the highest error rate occurs during 48 hours after the aerobic exercise. After this time, little progress in five days of the aerobic exercise has still not reached the performance level of the acquisition, indicating the minimum memory loss in this period of time. Roig *et al*. (2012) argued that no effect of the aerobic exercise on the acquisition of motor skills in a short time may be related to fatigue caused by the aerobic exercise, leading to a reduction in the accuracy of the tracking task (Roig, *et al*., 2012). Recent evidence suggests that moderate-intensity aerobic exercise may have harmful effects on the accuracy of performance(McMorris, *et al*., 2011). Some researchers have suggested that the choice of the type of cognitive training and protocol specification can be effective in improving performance (Lambourne & Tomporowski, 2010). Kantak *et al*. (2012) reviewed the findings of 41 studies on motor skills. The results showed that 19 studies indicate a significant difference between groups in the delayed retention tests.

One reason for the difference in findings is the type of task. The task for the short serve in badminton as a single task is different from the task used in the study of Roig *et al*. (2012). Roig *et al*. (2012) used the tracking and permanent task. The difference in the nature of the task in the present study and the task used in the study of Roig *et al*. (2012) can be the reason for the differences in findings.

Roig *et al*. (2012) used the aerobic exercises at 65% to 70% of maximal oxygen consumption similar to the present study. One of the findings was a significant difference in the memory consolidation test. It seems that no significant impact of the aerobic exercise at 65% to 70% of maximal oxygen consumption on the acquisition and the immediate retention are due to the features of the task in the present study. It is likely that the lower-intensity aerobic exercise affects a single task, such as the short serve in badminton (Roig, *et al*., 2012). For example, Joyce *et al*. (2009) used the aerobic exercise at 40% of maximal oxygen consumption, but no significant results were observed after training (Joyce, 2009).

It seems that there is a kind of exchange between the effects of the aerobic exercise on the cognitive performance and the short serve. Research findings show the effect of the aerobic exercise on the immediate cognition (Hogervorst, 1996; Lichtman & Poser, 1983). They have proven this effect on the motion performance in the delayed retention (Phillip D Tomporowski, *et al*., 2005). The results of the present study support these findings and indicate the effect of aerobic exercise on short serve performance (as a single motor activity) up to 5 days. It can be concluded from these findings that the low cognitive load (such as performing the short serve in badminton) can reduce the impact of the aerobic exercise at 65% to 70% of maximal oxygen consumption on motor function. In contrast, increasing the cognitive load and time for performing tasks (such as the tracking task) enhances the effect of the aerobic exercise on motor function. According to the obtained results, a moderate-intensity aerobic exercise can have a positive effect on cognitive function, learning and memory processes (Lambourne & Tomporowski, 2010; Roig, 2013). Also, performing an aerobic activity moderates memory and has a positive impact on it. The studies include the effect of aerobic exercise on short-term memory(Coles & Tomporowski, 2008; Pontifex, 2009; Sibley & Beilock, 2007; Phillip D Tomporowski, *et al*., 2005) and long-term memory(Coles & Tomporowski, 2008; Labban & Etnier, 2011; Potter & Keeling, 2005), which supports the hypothesis. The researchers argued that medium and high intensity aerobic exercise can improve the speed of response in the working memory and has little or harmful effect on the accuracy of movements. Decreasing accuracy may be due to an increase in concentrations of catecholamines, leading to an increase in motor noise and a decrease in accuracy(McMorris, *et al*., 2011). It is not clear if the cognitive-motor intervention in a simple task can be observed in other intensities of the aerobic exercise by controlling the conditions of the experiment.

It should be noted that using the task of the serve in badminton as a single task can enhance the process of learning, but cannot indicate the impact of the aerobic exercise well. One reason is low impact of the aerobic exercise that makes it difficult to measure. In fact, the maximum effect of the aerobic exercise is much less than the effect of the exercise on samples. With regard to the content of the task in the study, the aerobic exercises are ineffective. In fact, this problem can be attributed to a lot of research in this area. Therefore, it is necessary to revise the methodology. This is one of the common challenges in studies on the motor behavior (Schmidt & Lee, 1988). It is likely that the effect of aerobic exercises on accuracy can effectively be investigated using more limited tasks with less degrees of freedom. According to these reasons, future research can use more limited tasks and those associated with lower learning to investigate the effect of the aerobic exercise.

CONCLUSION

The results of the study indicated that the aerobic exercises before training at 65% to 70% of maximal oxygen consumption is more effective than the aerobic exercises after training in reducing the rate of the motion error, increasing the accuracy, and improving the short serve in badminton. It is likely that this result is true for other short-term tasks. An idea can be used to compare the single and continuous tasks in terms of the effectiveness of the aerobic exercise at 65% to 70% of maximal oxygen consumption and control these effects. The findings also could potentially be affected by a cognitive-motor intervention. The type of the task and the cognitive requirements can determine the level of the intervention. However, more research is needed to investigate the exact effects of different intensities of aerobic exercises on various tasks in terms of the features of the motor control and provide practical results.

ACKNOWLEDGEMENT

We are most grateful to all subjects for their participation.

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