

The Comparison of Muscles Stretching and Ice Massage on Lactic Acid Levels In Half Time Interval Football Match

Wattana Nuttouch¹
Ashira Hiruntrakul²

บทคัดย่อ

การสะสมของกรดแลคติกในปริมาณมากในกล้ามเนื้อของนักฟุตบอล จากการแข่งขันฟุตบอลทำให้ประสิทธิภาพ และสมรรถภาพของนักฟุตบอลลดลง การทำให้ร่างกายพื้นสภาพขณะหยุดพักระหว่างการแข่งขันฟุตบอลที่มีช่วงระยะเวลาสั้นๆ เพื่อลดระดับกรดแลคติกซึ่งมีความสำคัญ เพื่อที่จะทำการแข่งขันต่อไปได้ในช่วงครึ่งเวลาหลัง ดังนั้น การศึกษานี้จึงมีวัตถุประสงค์เพื่อเปรียบเทียบผลการยืดเหยียดกล้ามเนื้อและการนวดด้วยความเบ็นต่อระดับกรดแลคติกในนักกีฬาฟุตบอลชาย อาชีพระหว่างช่วงพักครึ่งการแข่งขัน โดยเป็นการศึกษาแบบไขว้ ในอาสาสมัครนักกีฬาฟุตบอลชายอาชีพจำนวน 10 คน (อายุเฉลี่ย 21.30 ± 1.83 ปี) ทำการจำลองการแข่งขันกีฬาฟุตบอลและให้นักกีฬาทำการพื้นสภาพ 3 วิธี คือ การนั่งพัก การยืดเหยียดกล้ามเนื้อแบบคงที่ และการนวดด้วยน้ำแข็ง เป็นเวลา 7 นาที โดยเว้นช่วงห่างกัน 1 สัปดาห์ วิเคราะห์ข้อมูลการเปลี่ยนแปลงของกรดแลคติกก่อนการแข่งขัน, หลังการแข่งขัน 45 นาทีทันที และหลังการพื้นสภาพ

ผลการศึกษาพบว่า การนวดด้วยน้ำแข็งทำให้ระดับกรดแลคติกลดลงภายหลังจากการแข่งขันทันทีเมื่อเปรียบเทียบ กับภายนอกการพื้นตัว ($p<0.05$) และระดับของกรดแลคติกในกลุ่มของการนั่งพักและการนวดด้วยน้ำแข็งมีความแตกต่างกัน อย่างมีนัยสำคัญทางสถิติ ($p<0.05$) นอกจากนี้ พบว่าวิธีการทำให้ร่างกายพื้นสภาพทั้ง 3 วิธี มีผลทำให้ค่าเฉลี่ยของอัตราการเต้นของหัวใจลดลง ($p<0.05$) การศึกษานี้ชี้ให้เห็นว่า ผลของการพื้นสภาพร่วงกายของนักฟุตบอลด้วยการนวดน้ำแข็ง ช่วยลดระดับกรดแลคติกและความเหนื่อยล้าของกล้ามเนื้อในช่วงพักครึ่งเวลาได้ ซึ่งเป็นประโยชน์ต่อนักกีฬาและผู้ฝึกสอนที่สามารถนำไปใช้ในการพื้นฟูร่างกายในระหว่างการแข่งขันหรือออกกำลังกาย โดยเฉพาะอย่างยิ่งในกีฬาที่มีระยะเวลาการแข่งขันที่ใช้เวลานาน และมีช่วงพักระหว่างการแข่งขันเป็นช่วงสั้นๆ

คำสำคัญ: กรดแลคติก, การพื้นสภาพ, การนั่งพัก, การยืดเหยียดกล้ามเนื้อแบบคงที่, การนวดด้วยน้ำแข็ง นักกีฬาฟุตบอลชาย อาชีพ

Abstract

The accumulation of large amounts of lactic acid in the muscles of footballers from football matches affect to reduce the efficiency and performance of footballers. Thus recovery while resting period a short break of football match for reduce the lactic acid level is important. In order to continue to play in the second half. Therefore, this study aimed to compare the effect of static stretching and ice massage on lactic acid levels in professional footballers during halftime which a cross-over study design in 10 professional male footballers (average age 21.30 1.83 years). After simulating football matches, the footballers received the recovery methods by sit and rest recovery, static muscles stretching and ice massage. Each method was 1 week apart. Analyze data for changes in lactic acid levels at pre-test, immediately after competition 45 minutes and after recovery. The study found that ice massage can reduces the lactic acid levels immediately after the match compared to after the recovery ($p <0.05$) and significant difference from sit and rest recovery ($p <0.05$). In addition, this was found that all 3 recovery methods resulted in a decrease in the average heart rate ($p <0.05$). This study indicates that the effect of ice massage can recovering a football player's body and help to reduce lactic acid levels and muscle

¹Master of Sciences Exercise and Sport Sciences Graduate School, Khon Kaen University

²Sports and Exercise Science program, Faculty of Apply Science and Engineer, Khon Kaen University, Nong Khai Campus



fatigue during the half time break. Which is beneficial to athletes and trainers. It can be used for body recovery during competitions or exercise, especially in sports with limited competition periods such as volleyball, basketball, rugby, tennis, badminton and hockey.

Keywords: lactic acid, recovery, sit and rest, static muscle stretching, ice massage, professional male footballer

Introduction:

Background

At present, football is popular among people of all ages, both domestically and internationally. Many competitions are organized both in the country and abroad, such as SEA Games, Asian Games and Olympic Games. Due to the popularity of football, there are the competitions in training the skills of players and coaches as well as effective team management in order to be able to beat competitors. When there is high competition, the knowledge of sports science, namely sport physiology, nutrition and sport psychology is used to enhance the efficiency of the players for effective training and sports playing without danger and injury (Fangsaken, 2006) because footballers have to be in the game for a long time and their body is heavily used for maximum effectiveness. The football match is separated into 2 periods: 45 minutes each. There is a half-time interval of not more than 15 minutes. When the body is working hard in the first half, the ability of the footballers will decrease in the second half. This may be because most of the energy used for efficient movement of the body is derived from anaerobic energy metabolism. The energy obtained from this type of metabolism has a high level of capability. At the same time, it causes waste products since the energy generation process is caused by incomplete separation of glucose. For this reason, oxygen cannot be used in time. The main waste product is lactic acid that occurs immediately after exercise. It is accumulated in muscles and blood. It will first occur in the muscles cells and

spread into the bloodstream. It is accumulated more in the working muscles than in the bloodstream. When lactic acid is accumulated in a large quantity, it interferes with muscle function, resulting in decreased muscle performance and difficult muscle movements. The study found that lactic acid is a major cause of fatigue (Lamb, 1984). This is consistent with Bruce (2000) which stated that lactic acid is the first factor that causes muscle soreness, resulting in muscle fatigue. When the rate of lactic acid accumulation increases, athletes' efficiency and performance will decrease.

Footballers, basketball players, hockey players and rugby football with 15 players have a short half-time interval (10-15 minutes), so it is important for them to quickly recover to the normal condition. A lot of studies have conducted to find out the ways to help the body recover to the normal condition after exercising, such as rest recovery, cold water immersion, ice massage, sitting and cooling, sitting with basic body movements, sitting and muscles stretching, static stretching with sauna and walking meditation (Jumsai Na Ayudhya et al., 2011; Rattanasateankij, 2000; Amatayakul, 2012; Thongho, 2016; Willcock, 2005). These methods will allow the body to recover to the normal condition faster, especially cold treatment. For example, the studies about the effects of ice massage, ice massage with water immersion and ice massage with aquatic exercise upon the recovery of muscle after exercise induce delayed onset muscle soreness (Permpet, 2008), and the comparison of the effects among various recovery methods after exercise on athletes' performance were conducted (Gomenake, 2008).

When the body is exercising, the body temperature will rise and the body will have to get rid of heat. The circulation system will work harder and the heart will pump more blood into the skin to help release heat from the body using the vasomotor system. If the body temperature rises after exercise or while resting during the competition, the body's systems will still work to release heat from the body. Therefore, cold treatment will help the body recover to the normal condition faster. Nowadays, using cold water or ice applying on the body is convenient and commonly used to help body recover (Bouzid et al., 2018).

From the study and review of the relevant documents mentioned above, the researcher has recognized the benefits of helping the body of the athletes to recover after exercising or while resting during a short break and to reduce the lactic acid that causes fatigue and to be ready to continue to compete within the limited break period. However, it is still suspected that which method between stretching and ice massage in professional footballers during the half time interval football match will allow the body to recover and reduce the amount of lactic acid faster. From the literature review, it was found that few studies were conducted on this issue. Most of them studied about after exercise or after the match. No studies have been conducted on the half time interval. For this reason, the researcher was interested in comparing the two recovery methods in order to find out the differences in both methods and to choose the method that benefits the footballers having a short half time interval during the football match or to apply it to other sports such as basketball, rugby football, volleyball and hockey.

Objective:

To study muscles stretching and ice massage in half time interval football match that

affect the lactic acid levels of professional footballers

Participants and Methodology:

Participants

A sample of convenience of 10 professional male footballers of KKFC who has played in Thai League 2 and has been a professional athlete for at least 2 years, Average age $21.30, \pm 1.83$ years, Height 169.30 ± 4.74 cm, Weight 63.90 ± 6.12 kg, Blood pressure $122.20/69.20$ mm/hg, Resting heart rate 67.10 ± 2.92 bpm, Participants were professional male footballers recruited from KKFC which played in the Thai League 2 Football Tournament 2019 season. The inclusion criteria consisted of having a professional, aged between 19-35 years and having regular training at least 5 days a week without injury. All participants were consent to do blood test and able to participate in the study until the end of the study. Any participants having other conditions that might affect training such as ankle sprain or musculoskeletal system pain with a pain score of at least 5 out of 10 on a visual analog scale or fever were excluded from participation in the study. This study was approved by the Khon Kaen University Ethics Committee for Human Research before participation in the study (HE581392).

Methodology:

This study was a cross-over study design which aimed to compare the effects of the static stretching and ice massage on lactic acid levels in half time interval football match. This research was separated into 3 groups based on the recovery methods including; Group A (sit and rest after competition), Group B (static stretching after competition), and Group C (ice massage after competition). It took 3 weeks to complete the research.



For the first time, the eligible participants ($n = 10$) were interviewed and screened for eligibility based on the study criteria, including demographics (i.e., age, gender, weight, height, position) and baseline characteristics (i.e., resting heart rate, resting blood pressure, lactic acid levels) (pre-test; T1). All participants stopped doing exercise or sporting events and avoided alcohol, cigarettes and caffeine-containing beverages, before and during the study. Then, they were randomly arranged the order of the recovery methods to be received all three times by using the random number table. This study divided the recovery methods into 6 sets, consisting of ABC, ACB, BAC, BCA, CAB, and CBA.

Thereafter, all participants were recruited to play a simulation football match for 45 minutes. The same rules as the actual competition were employed. Mor Din Daeng FC was invited for the competition at the training field of the Khon Kaen FC. The competitions were held at the same time at 05.00 p.m. The same players were used throughout the 3 competitions to simulate the match. After the competition, the heart rate and the lactate acid levels of the participants were assessed (immediately after the competition; T2). Then they were involved in the recovery programs based on the random number table. Subsequently, their heart rate and lactate acid levels were assessed (after recovery methods; T3).

For example; the first participant received the second set (ACB) according to the random number table. For the first time (first week), this participant received sit and rest (Group A) after the competition. In the second time, this participant was ice massaged (Group C) and in the last week, the participant was static stretched after the competition (Group B).

All participants were involved in the recovery methods according to their groups. Each method took about 7 minutes. Then the

outcomes were measured immediately after the competition and after the recovery methods were applied.

Intervention methods:

The participants were involved in the recovery methods according to their groups, including the sit and rest, static stretching and ice massage. The details of the recovery methods are explained below.

Sit and rest

The participants in group A were instructed to sit and rest for 7 minutes after the competition simulating a 45 minutes football match. They sat and drank water to relax themselves before the match in the second half.

Static stretching

The participants in group B were instructed to do static stretching in total body muscle, emphasizing lower extremities muscle. The research assistants helped with the stretches for athletes in each position (total of 13 positions; the details of each position are explained in Appendix E) for 7 minutes. During stretching, they had to try to stretch until feeling very tight without hurting and hold for 10-15 seconds. During the movement, they should not move in the form of a twitching, pulling or biting and normal breathing.

Ice massage

The participants in group C were instructed in long sitting position. Then they were massaged by the research assistant (one research assistant per one football player) using crushed ice put in a zip-lock bag (ice bag) at a temperature of $0\pm2^{\circ}\text{C}$. The research assistant rubbed the ice bag to massage the athlete's thigh and moved the ice bag in a circle over the muscles in up and down direction following the longitudinal muscles,

focusing on the hips, thighs, hamstring and calf muscles for 3 minutes/side. Then the back and the shoulder were massaged for 1 minutes, a total of 7 minutes. Deep kneading technique was used to massage in this study by the research assistant who trained by the researcher for 30 minutes.

Outcome measurement:

Instrumentation

1. Blood sampling equipment set (Brand: Acuu-Chek safe-t-pro uno Lanset.)
2. Lactic acid level analyzer (Brand: Lactate Plus; manufactured by Nova biomedical in America.)
3. Lactate test strip and puncture needle (Brand: Lactate Plus; manufactured by Nova biomedical in America.)

Blood lactate levels:

The blood lactate levels test was performed a total of 3 times (the 1st time was before the simulation of a 45 minutes football match, the 2nd time was after the match immediately and 3rd time after recovery methods). This was done based on the medical principles and methods.

Statistical analysis:

Descriptive statistics were used to explain baseline demographics, participant characteristics and findings of the study. The repeated measure ANOVA was utilized to analyze

the lactic acid level between the groups (baseline, and data after the 1st and the 2nd recovery). An analysis of covariance (ANCOVA) was utilized to compare the magnitude of changes between the groups after the 2nd recovery. The level of statistical significance was set at $P < 0.05$.

Results:

Sit and rest recovery (group A). The participants in the group A showed no significant reduction in the lactic acid levels at immediately after competition and after recovery (p -value > 0.05).

Static muscle stretching (group B). In this group, the lactic acid level significant difference between pre-test and immediately after competition and pre-test and after recovery (p -value < 0.05). However, there was no significant difference at immediately after competition and after recovery (p -value > 0.05).

Ice massage (group C). The participants in ice massage group showed significant reduction in the lactic acid level when compared between immediately after competition and after recovery (mean difference was 2.73 mmol/L) (p -value < 0.05).

The ANCOVA analysis indicated that the reduction of the lactic acid level in group C was significantly differences from the group A (p -value < 0.05 , Table 11 and Figure 12). However, there was no significantly differences in the group B and group C (p -value > 0.05).



Table 1 Compared the lactic acid levels and heart rate at pre-test, immediately after competition and after recovery effect in among 3 recovery methods; sit and rest recovery (group A), muscles stretching (group B), and ice massage (group C) (N=10)

Variable	Group A		Group B		Group C		A-B ^a	A-C ^a	B-C ^a
	Mean±SD	Mean diff	Mean±SD	Mean diff	Mean±SD	Mean diff			
<i>Lactic acid level^b</i>									
Pre-test	4.85±3.40 (2.41 to 7.29)		2.75±1.29 (1.82. to 3.68)		3.41±0.79 (2.84. to 3.98)		2.10	1.44	-0.66
Immediately after competition	5.98±2.98 (3.84 to 8.11)	-1.13	5.40±2.38 (3.69 to 7.10)	-2.65	6.93±2.17 (5.38 to 8.48)	-3.52	.58	-0.95	-1.53
After recovery	5.63±2.76 (3.66 to 7.60)	-0.78	4.11±1.73 (2.87 to 5.35)	-1.36	4.20±1.70 (2.98 to 5.42)	-0.79	1.52	1.43	-0.09
<i>Heart rate^b</i>									
Pre-test	69.1±3.76 (66.41 to 71.79)		69.1±2.0 (67.15to 71.05)		69.3±3.4 (66.87 to 71.73)		0.00	-0.20	-0.30
Immediately after competition	166.5±11.52 (158.26 to 174.74)	-97.4	166.1±11.82 (157.65to 174.55)	-97.0	166.2±10.25 (158.87 to173.53)	-96.9	0.40	0.30	-0.10
After recovery	103.3±3.83 (100.56 to 106.04)	-34.2	102.20±5.35 (98.37to 106.03)	-33.1	100.70±3.83 (97.96to 103.44)	-31.4	1.10	2.60	1.50

Note: The data were presented using mean \pm standard deviation. ^aThe data between the three groups (A, B and C groups) were analyzed using the ANOVA. ^bThe data among repetitive measured (pre-test, immediately after competition and after recovery) using the repeated one-way ANOVA.

Table 2 Compared the lactic acid levels and heat rate between immediately after competition and after recovery in among 3 recovery methods; sit and rest recovery (group A), muscles stretching (group B), and ice massage (group C) (N=10)

Variable	Group A	Group B	Group C	Mean	Mean	Mean
	Mean	Mean	Mean	diff (A-B)	diff (A-C)	diff (B-C)
Lactic acid level	5.71 ^a	4.57 ^a	3.66 ^a	1.14	2.05 ^{*c}	0.91
Heart rate	103.29 ^b	102.21 ^b	100.7 ^b	1.08	2.58	1.51

Note: The data were presented using mean. The data between group the three groups (A, B and C groups) were analyzed using the ANCOVA., ^a Covariates appearing in the model are evaluated at the following values: data = 6.1033. ^b Covariates appearing in the model are evaluated at the following values: data = 166.2667. * The mean difference is significant at the .05 level ($p<0.05$). ^c Adjustment for multiple comparisons: Bonferroni.

Discussion:

This study compared the lactic acid levels and the heart rate levels in half time interval football match of 10 professional footballers from Khon Kaen FC using 3 recovery methods; sit and rest recovery (group A), static muscle stretching (group B) and ice massage (group C). It took 7 minutes for recovery. Seven minutes were the possible recovery time during the half time interval because football players only had 15 minutes of the half time interval before they started competing in the second half. So, they had only about 7 minutes to recover the body in various ways. Also, in the previous studies the recovery period studied were less than 5 minutes or more than 10 minutes. The study was conducted 3 times using cross-over study design. Each recovery method was 1 week apart. The results of the study found that the participants had normal resting heart rate and aged approximately 21 years old. In terms of physiological parameters related to exercise which

can be beneficial for athletes, sports trainers and general people, this research studied acute effects, not chronic effects of the physical recovery. Therefore, to obtain reliable comparison data and reduce data discrepancies, all samples were treated by 3 recovery methods; sit and rest recovery, static muscle stretching and ice massage (group C) (cross over design) in order to compare experimental results among 3 methods. In addition, the researcher used effective sports science tools and relevant variables in the study. The experimental results will be discussed by the following topics.

Ice massage

In this research, it was found that ice massage reduced the lactic acid levels in the blood and the heart rate after the competition with statistical significance (p -value <0.05 , Table 8). It can reduce lactic acid levels better than sit and rest and muscle stretching with non-statistical significance. Ice massage is a combination of deep massage that helps with the movement of lactic acid and the use of cold treatment, which contributes to the flow of blood, increases oxygen levels and muscle metabolism and reduces muscle spasm and heart rate. This results in sufficient blood supplying to the muscles to exchange substances between outside and inside the cell. It may also eliminate waste that occurs in the muscle system such as lactic acid. Moreover, Vejbaesya and Palavivatana (1993) found that massage causes the body to release



histamine and acetylcholine, which are the substances that cause blood vessels to dilate. So, there is an increase in blood flow, and more blood counts are released from the spleen. Also, deep massage increases blood flowing to the arms and legs and the flow of lymph. Thatsanasawang (1987) stated that the lymph will help eliminate lactic acid from the muscles through the bloodstream, which will be filtered through the kidneys and driven out. The temperature of the massage is 0 ± 2 degrees Celsius. The massage should not be held anywhere for longer than 2-3 minutes because it can cause skin injury.

Static muscle stretching

Static muscle stretching recovery causes the heart rate to decrease, but it does not help reduce the lactic acid levels after the competition. Stretching is based on the principle of contracting the muscles that need to be stretched for a period of time, then alternate and change the side. It will help improve the blood circulation system and the flexibility of the stretched muscles. So, more oxygen can be used to burn lactic acid in the stretched muscles. Most muscles that work while exercising are striated muscles with red fibers that have good lactic acid oxidation properties since the red fibers contain a lot of oxygen. This indicates that lactic acid in the blood can be reduced when stretching the muscles. It is also in accordance with the study of Sriyabhaya (2002). The important thing is that muscle stretching helps improve blood circulation, causing blood to flow to the active muscles. The previous study found that stretching after exercise had an effect on lactic acid concentration level and heart rate in soccer players (Soongpuk, 2014). Stretching after exercise in each position took approximately 10-30 seconds for 10 minutes. However, in this research, there was a limit because of the halftime interval of football matches was just 7 minutes. Therefore, static

muscle stretching can be done in just 7 minutes. As a result, the effect of the static muscle stretching on the reduction of lactic acid level was not statistically significant. However, it was found that static muscle stretching can reduce the lactic acid levels better than sit and rest recovery without statistical significance.

Sit and rest

Sit and rest recovery is a common physical recovery, which will allow the various systems to recover naturally. It is a sudden reduction in body function after the body has a high intensity exercise. While sitting and resting, the body will begin the recovery process such as ATP synthesis or the elimination of waste such as lactic acid from muscles and blood. However, sitting for only 7 minutes did not help reduce the lactic acid levels in the blood (p -value > 0.05). There was a study of sit and rest recovery affecting the decrease of lactic acid level in the blood. The subjects sat and rest at normal temperature and drank water at normal temperature for 1 hour. Sit and rest recovery is commonly used. The study also found that after stop exercising, the heart rate dropped sharply in the first minute. It dropped by approximately 40-60 times per minute and would gradually decrease while resting. The halftime interval of football matches was limited to only 7 minutes for recovering the heart rate. So, the results from all 3 recovery methods were not different.

When comparing the three recovery methods by ANCOVA, it was found that the lactic acid levels in the blood of sit and rest recovery and ice massage groups were different with statistical significance (p -value < 0.05). After the match and recovery, the ice massage group can reduce the lactic acid levels in the blood than the sit and rest recovery group. It is because deep massage with ice will stimulate blood circulation. Deep massage will help the blood

supply into the muscles twice, causing the muscles to exchange fluid and drain waste which is lactic acid faster. Also, the coldness from the ice helps the blood flow back to the heart more, causing the amount of blood that is pumped out to increase, resulting in more exchange of fluid. The recovery during the half time interval required the football players to recover from fatigue and be ready to compete in the second half with reduced heart rate levels. However, the heart rate levels should not decrease to the same level as before exercise because the body of the football players must ready to compete in the second half without having to warm up again. Therefore, this study showed that even if the heart rate decreased due to recovery, it was still higher than before competing.

Conclusion

This study aimed to investigate the effects of recovery methods on the lactic acid levels and heart rates and to choose the method that benefits the footballers having a short half time interval during the football match. The researcher chose 3 recovery after exercise methods to compare these effects; sit and rest recovery, static muscle stretching and ice massage each method took 7 minutes for 1 week in 10 professional football players from Khon Kaen FC. This study found that ice massage can reduce the lactic acid levels when compared with sit and rest recovery after recovery period. While, ice massage and static muscle stretching showed no difference. In addition, the lactic acid levels and heart rates decreased after recovery in ice massage group. For others groups, only heart rates can be reduced. The present study finding have clinical impacts recovering the physical condition of professional footballers in order to reduce lactic acid levels and muscle fatigue during the half time interval. Moreover, these findings may

be beneficial for athletes and trainers for body recovery during competitions or exercise, especially in sports with a lengthy competition period and there is a brief break between matches

Suggestions for further study

1 For the static muscle stretching, it takes less time to stretch (15 sec). So, in this study, there were no significant differences after recovery. In further study, more time (20-30 sec) will be needed to find differences in this method. Addition, using dynamic or specific stretches for remover may provide different results.

2. For further research, the effects of recovery on delayed onset of muscle soreness (DOMS) after exercise apart from the lactic acid levels can also be investigated.

Acknowledgements

Thankfulness also Khon Kaen Football Club and Professional Football Players for participating in my research.

Authors' contributions

Master of Sciences Exercise and Sport Sciences ,Graduate School ,Khon Kaen University

Reference

1. Amatayakul A. (2012). *Comparison of acute effect of proprioceptive neuromuscular facilitation stretching and static stretching on motor performance in amateur male football players*. [Master Thesis in Sport sciences]. Chiang Mai: The Graduate School, Chiang Mai University. [in Thai].
2. Bouzid et al. (2018). Faster physical performance recovery with cold water immersion is not related to lower muscle damage level in professional soccer players.



3. Bruce, L. (2000). The role of skeletal muscle in lactate exchange during exercise introduction. *Medicine & Science in sports &Exercise*. 32: 753-755.
4. Faengsaken M. (2006). *Sport and health*. Bangkok: O-Dean store. [in Thai].
5. Gomenake S. (2008). *A comparison of the effects among various recovery methods after exercise on athletes' performance*. [Master Thesis in Sport sciences]. Bangkok: The Graduate School, Chulalongkorn University. [in Thai].
6. Jumsai Na Ayudhaya C, Arkarapanthu A and Ruangthai R. (2011). Effects of recovery methods on running speed and ball-passing accuracy of futsal players. *Kamphaengsean Acad J*; 9(1): 61- 9. [in Thai].
7. Kaewkungwal J. (2011). *Textbook of clinical research*. Mahidol publishing, Bangkok. [in Thai].
8. Lamb,D.R. (1984). *Physiology of Exercise*. Now York: Macmillan Co.
9. Palavivatana K. (1989). *Manual, self-healing with heat and cold*. Bangkok: Mho Chao Bann. [in Thai].
10. Peampet S. (2008). *The effect of massage with ice massage with water immersion and ice massage with water exercise towards the recovery of muscles after the muscle strain from exercise*. [Bachelor Thesis in Sciences]. Bangkok: The Graduate School, Kasetsart University. [in Thai].
11. Rattanasateankij W. (2009). *Effect of cold water immersion on recovery and performance*. [Master Thesis in Sport sciences]. Bangkok: The Graduate School, Srinakharinwirot University. [in Thai].
12. Sriyabhaya A. (2001). *The effect of resting, stationary stretching and sauna on lactic acid levels in the blood and heart rate*. [Bachelor Thesis in Sciences]. Bangkok: The Graduate School, Kasetsart University. [in Thai].
13. Sungpook N. (2014). *Effect of recovery type after exercise upon lactic acid concentration level and heart rate in soccer players*. [Doctor of Philosophy Program in Physical Education]. Bangkok: The Graduate School, Kasetsart University. [in Thai].
14. Thatsanasawang C. (1987). *Massage techniques for athletes*. United book, Bangkok. [in Thai].
15. Thongho I. (2016). *Effect of recovery after exercise methods on lactic acid in the blood, heart rate and anaerobic performance in athletes*. [Master Thesis in exercise and sport science]. Chonburi: The Graduate School, Burapha University. [in Thai].
16. Vejbaesya C and Palavivatana K. (1993). *Physiology of exercise*. 4th ed. Thummaklomkarnphim, Bangkok. [in Thai].
17. Willcock, I. (2005). *The effect of water immersion, active recovery and passive recovery on repeated bouts of explosive exercise and blood plasma*. Master of Health Science. Auckland University of Technology.