Hydration status, sprint performance and physiological responses during repeated sprint ability (RSA) training session

Raiza Sham Hamezah
Universiti Pendidikan Sultan Idris (UPSI)

Normah Jusoh
Universiti Pendidikan Sultan Idris (UPSI)

Nur Ikhwan Mohamad
Universiti Pendidikan Sultan Idris (UPSI)

JPASPEX (2014) **2(2),** 06-16
http://www.jpaspex.com
e-ISSN 2289-5817

Research article

Hydration status, sprint performance and physiological responses during repeated sprint ability (RSA) training session

Raiza Sham Hamezah ✉, Normah Jusoh, Nur Ikhwan Mohamad
Faculty of Sports Science & Coaching, Sultan Idris Education University

Abstract

The aim of this study to investigate the relationships among hydration status level, sprint time performance capabilities and physiological responses [blood pressure, heart rate and rate of perceived exertion (RPE)] during a 15m Repeated Sprint Ability (RSA) training session. Fifteen male participants with a mean age 21 ± 1 years old, total mean body weight of 63.21 ± 8.25kg, and mean body height of 1.68 ± 0.05m voluntarily participated in this study. The participants underwent an RSA session with all measurements of interest were conducted pre, during and post session. Paired sample t-test was used to analyse the hydration status (urine specific gravity), with repeated measure ANOVA was used to compared the sprint time and physiological responses. Pearson correlation was utilised to determine the relationship between hydration status, sprint time, heart rate response, blood pressure and RPE during the training session. The results indicated no significant changes in hydration status. However, there was a significant difference in body mass loss before and after the training. Sprint time performance indicated no significant differences between all sets involved, indicating steady state sprint performance. The physiological responses showed a significance increase during this 15m sprint training. Correlation values for sprint time and RPE versus hydration status demonstrate a significant and strong linear relationship. As a conclusion, 15m RSA for 3 sets of 5 repetitions have no significant effects on hydration status, with sprint time performance are not influenced by hydration during an RSA session. However, as participants trying to maintain sprint time performance, physical stress do increase and thus making it difficult to improves sprint time performance. Further studies on muscle metabolic factors are suggested for future research works.

Keywords: Blood pressure, heart rate, hydration status, RSA, sprint time

Introduction

Maintaining hydration status is considered important for sports performance as well as physical well-being. Neural, hormonal, metabolic and mechanical aspects involved in any physical training including sprint training are greatly influenced by the level of fluid available in the body (Kraft, et al., 2010). Fluid or water plays a fundamental role in the body as it functions as the solvents for nutrients, transport of nutrients to muscle cells, helps body eliminates waste products, maintenance of constant body temperature and protection of the fetus during pregnancy (Armstrong, 2007; Sawka, et al., 2007). A number of methods have been used to assess and quantify hydration status and changes in hydration status. Acute changes in body mass over a short time period can frequently be assumed to be a result of body water loss or gain as 1ml water has a mass of 1g and therefore changes in body mass can be used to quantify water gain or loss (Lentner, 1981). Other methods in assessing hydration status are by measuring blood and urine indices while determination of perception of thirst is categorized as a subjective method in hydration assessment (Armstrong, 2007, Gonzalez-Alonso, Calbet & Nielsen 1999; Shirreffs, 2000).

Maintaining an appropriate level of hydration status during training may positively influence blood volume, cardiac output (Gonzalez-Alonso, Mora-Rodriguez, & Coyle, 2000) muscle blood flow (Gonzalez-Alonso, Calbet, & Nielsen, 1998, 1999), core and muscle temperatures (Murray, 2007). Dehydration of approximately 3% body mass loss has deleterious effects in physiological and performance-influencing variables such as reduced motor performance, reduced muscular endurance, cardiovascular drift, reduced sweat rate, blood volume and heat dissipation in addition to heat illness (Heaps, Gonzalez-Alonso, & Coyle, 1994; Oppliger & Bartok, 2002; Sawka, 1992). This suggests that hypohydration is an important factor to consider when the athlete involve in exercise trainings, considering the effects on the adaptations in muscle, hormonal control, neural control, metabolism, and cardio-respiratory function with both aerobic and anaerobic trainings.

One previous study has indicated that there is no effect of moderate hypohydration or hyperthermia on anaerobic exercise performance in a temperate environment (Cheuvront, Carter, Haymes, & Sawka, 2006). Another study suggested that body mass reductions of 2–3% had no significant effect on sprint performance (Watson, et al., 2005).Thus, it is a question whether is there any relationship between hydration status, and sprint performance during the repeated sprint ability training session?

In terms of the repeated sprint ability (RSA), it is the ability to produce the best possible average sprint performance over a series of sprints (≤10 seconds), separated by short (≤60 seconds) recovery periods (Bishop, Girard, & Mendez-Villanueva, 2011). RSA is therefore an important fitness requirement for team-sport athletes. For activity pattern like short burst sprint, it consists of ≤6 -second) maximal work, with a single short sprint (5- to 6-second), adenosine triphosphate (ATP) is resynthesized predominantly from anaerobic sources (phosphocreatine [PCr] degradation and glycolysis), with a small (<10%) contribution from aerobic metabolism (Aerenhouts, Zinzen, & Clarys 2011; Boutcher, 2010). A typical sprint training session usually takes approximately between 40 minutes to 60 minutes; whereby the athletes will repeat the sprint for several repetitions. While the short sprint in a single manner does not affect hydration status, but repeated over several times for about one hour may have a significant effect on hydration status. The most important rule in generating the most benefits in long term training is to maximize acute stimulus and adaptation in each training session. Thus, if the single training session is lacking in terms of its` quality of performance (acute stimulus) due to hydration status, the cumulative adaptation longitudinally might also be impaired. However, this assumption is in need of further investigation, in which why this study was done. To conclude, the main aims of this research was to investigate the relationship of hydration status level, with their sprint time performance, heart rate response, blood pressure and rate of perceived exertion (RPE) during the RSA training session.

Methodology

Participants

Fifteen male participants aged 21.0 ±1 years old, total mean body weight of 63.21 ± 8.25kg, and mean body height of 1.68 ± 0.05m were recruited in this study. Participation was on voluntary basis and approval from the Faculty's Research Committee was obtained prior to data collection. The participants were healthy and free from injury during the time of the study, and had no serious injury records within the past 6 months that might affect the study outcomes.

Equipments

Body weight and height of the subjects were measured by using a weight scale (Omron HN-283, Kyoto, Japan) and stadiometer (portable Height Scale-Mentone/PE87, Australia) respectively. A digital hand-held `pocket` urine specific gravity refractometer PAL-10S (ATAGO, Japan) was used to assess hydration status along with hydration status colour coded strips; (AMES, Multistix 10SG Reagent Strips for Urinalysis, China) with sprint performance time were recorded using a stop watch (Q&Q,CAL.HS4, Tokyo, Japan). The 15-m sprint distance was measured using a digital roller measuring wheel. Portable wrist digital blood pressure monitor (HEM- 6200, Omron, Kyoto, Japan), was used to assess blood pressure and heart rate while Borg`s Scale was used to measure the rate of perceived exertion (RPE) across all repetitions. Environmental conditions were recorded using a Wet Bulb Globe Temperature (WBGT-103 Heat Stroke Checker, Japan).

Procedures

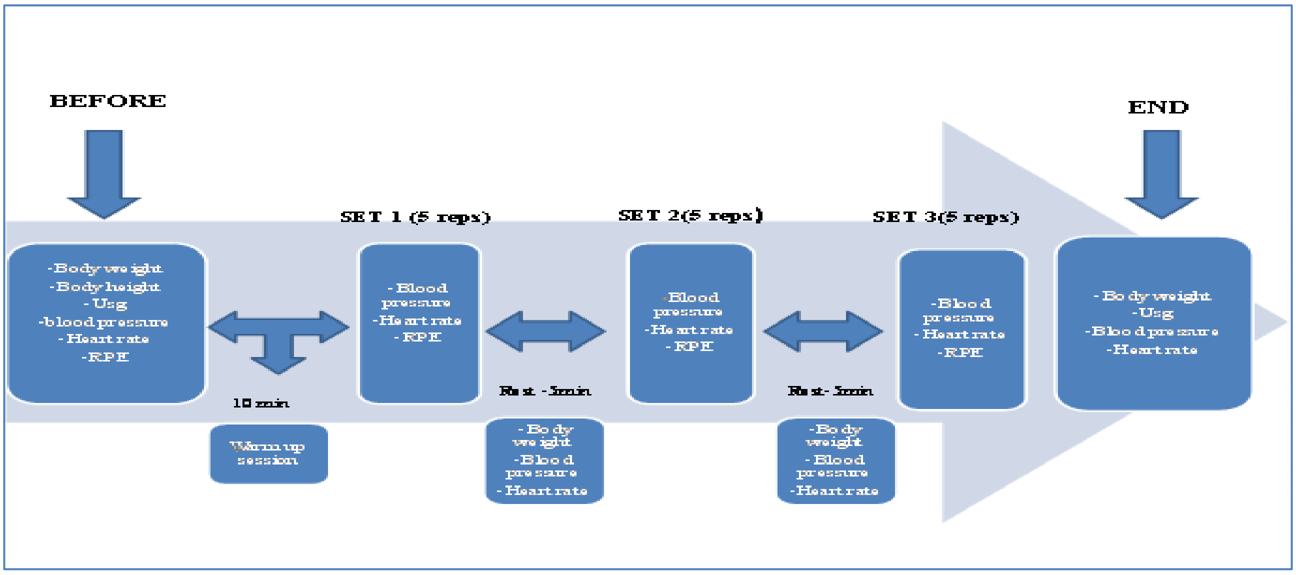
All participants attended two sessions. During the first session, the participants were briefed about the study, and were asked to sign the participation consent letter once all their questions had been answered; and the participants voluntarily indicated their willingness to participate in this study. Each participant was reminded that they were allowed to quit the study at anytime, without the need to give any reason for the withdrawal. Body height and pre-participation body weight were measured in session one, and Body Mass Index (BMI) were calculated from it. The participants were also told and demonstrated on how to correctly wear the blood pressure monitor on their wrist. The second session began with the measurement of body weight, urine specific gravity and blood pressure. The participants were then performed a standardized warm-up and stretching exercises, followed by specific warm-up. The specific warm-up for the training was in the form of five standardized athletic drills. The drills used were the ankling, high-knee, back-kick, chopping and easy stride. All drills were performed over a 10m distance with two repetitions each drill, except for the easy stride that covered a 30m distance.

The participants then performed a repeated sprint training program consisted of 5 repetitions of 15m sprint for each set, with total set performed were 3 sets. The duration for rest in-between each repetition was set at 60 seconds as suggested in the previous study on RSA training (Girard, et al., 2011). Rest in-between set was 5 minutes. Each participant was asked to sprint at maximal effort. Sprints were performed with a standing start split stance position with the dominant leg on the front, and all the participants were asked to wear their typically used sports shoes. Once started, the participants sprinted from 15m starting line to the finishing line, touching it with any foot, turning back and sprint back to the starting line for a completion of 1 repetition. All sprint times were recorded in the assessment form together with heart rate response, blood pressure and RPE scores (Borg, 1998; Chen, Fan, & Moe, 2002) before and after each repetition and set. Urine specific gravity was measured before and after the whole sessions, together with participants` body weight. Each urine specific gravity measurement was performed in 2 methods; refractometer and strips. Prior to the testing, the refractometer was calibrated with distilled water. Body weight was measured before, during and after training. WBGT was used to measure the environment temperature, humidity and wind speed during the session.

Statistical Analysis

Statistical Analysis for Social Sciences (SPSS) version 17.0 was used to perform all statistical analyses of the data collected, with alpha level for significant was set at 0.05. For descriptive data (body mass, age, height and BMI), mean and standard deviation of all participants were calculated. As all of the data had been determined normally distributed, urine specific gravity for both methods via refractometer and strips had been compared using paired sample t-test. Sprint time, heart rate, blood pressure and RPE comparisons were analysed using repeated measure ANOVA. Bonferroni post hoc test was used for significance differences found. Pearson Correlation was used to determine the relationship between hydration status and sprint performance (sprint time).

Figure 1: Schematic diagram of the study procedure



Results

Table 1 showed urine specific gravity (USG) level, measured by using 2 methods, which were refractometer and strip. There were no significance differences (p>0.05) for mean urine specific gravity for both refractometer and urine strip. No changes was observed for urine specific gravity (refractometer) between set 1(1.013 ± 0.010) and set 3 (1.013 ± 0.008). For urine specific gravity using the urine strips, the mean value was slightly lower during pre set 1(1.012 ± 0.007) than post set 3 (1.013± 0.008). On the other hand, there was a significant change in mean body weight, which was lower in post set 3 (62.97± 8.23kg) compared to pre set 1(63.21± 8.25kg). Mean for percent body weight loss was 0.38 ±0.14%.

Table 1: Urine Specific Gravity(USG) before and after 15m RSA sprint training. Values are Mean ± SD.

Variables	**Pre set 1 Mean ± SD**	**Post set 3 Mean ± SD**	**P value**
USG (refractometer)	1.013 ± 0.010	1.013 ± 0.008	0.984
USG (strip)	1.012 ±0.007	1.013± 0.008	0.803
Body mass (kg)	63.21 ± 8.25	62.97 ± 8.23	0.000*

*Significant at p<0.05

Table 2 indicates the results for the sprint time performance and physiological changes which includes blood presure, heart rate and rate of perceived exertion (RPE) throughout the training session. Results for mean sprint time showed no significant differences (p>0.05) across the training session. However, there were significant differences for mean heart rate (p<0.001), blood pressure (p<0.05) and RPE (p<0.001). Bonferoni post hoc revealed that mean heart rate during set 1 (122 ± 9bpm) was significantly lower (p=0.001) than set 2 (138 ± 12bpm). Likewise, mean heart rate during set 1 was significantly lower (p=0.005) than set 3 (144 ± 11bpm). On the other hand, there was no significance difference (p=0.450) between set 2 and set 3. Systolic pressure was significantly higher during set 1(143 ± 22mm/Hg) than set 2 (133 ± 13mm/Hg) and set 3(127 ± 18mm/Hg). While for diastolic pressure, was significantly higher during set 3(107 ± 27mmHg) than set 1(94 ± 17mmHg) and set 2 (87 ± 13mmHg).

Table 2: Sprint time, blood presure, heart rate and rate of perceived exertion (RPE) during 15m sprint training. Values are mean ± SD

Variables	**Set 1 Mean ± SD**	**Set 2 Mean ± SD**	**Set 3 Mean ± SD**	**P value**
Sprint time (s)	6.69 ±0.07	6.60 ±0.08	6.61 ± 0.11	0.393
Heart rate (bpm)	122 ± 9	138 ± 12	144 ± 11	0.000*
Blood pressure systolic (mmHg)	143 ± 22	133 ± 13	127 ± 18	0.021*
Blood pressure diastolic (mmHg)	94 ± 17	87 ± 13	107 ± 27	0.020*
RPE	4 ± 2	5 ± 2	6 ± 2	0.000*

*Significant at p<0.05

Pairwise comparisons showed there were significance RPE value for each set involved. Mean RPE was significantly higher during set 3 (6 ± 2) compared to set 2 (5±2) and set 1 (4±2), with p value stated p=0.000 and p=0.007 respectively. Similarly, mean RPE for set 2 (5±2) also was significantly higher (p=0.028) than set 1(4±2). To conclude, except the sprint time, the other physiological changes (heart rate response, blood pressure and RPE) showed a significance differences during this 15m sprint training.

Table 3 demonstrates the correlation Pearson results between hydration status and the sprint time, heart rate, blood pressure and rate of perceived exertion (RPE) during 15m RSA sprint training. There was a significantly high correlation between hydration status and sprint time (r=0.967, p<0.05) as well as RPE (r=0.896, p<0.05). On the other hand, there were a moderate correlation observed between hydration status and heart rate response (r=0.587, p>0.05) and weak correlation with systolic and diastolic blood pressure (r=0.475,p>0.05), (r=0.221, p>0.05).

Table 3: Correlation between hydration status, sprint time, heart rate, blood pressure and rate of perceived exertion (RPE) during 15m RSA sprint training

Hydration status vs:	R	P value
Sprint time (s)	0.967	0.012 *
Heart rate (bpm)	0.587	0.153
Blood pressure systolic (mmHg)	0.475	0.200
Blood pressure diastolic (mmHg)	0.221	0.336
RPE	0.896	0.037 *

*Significant at p<0.05

Environmental condition of pre, during and post RSA session indicated normal temperature for Malaysian climate as indicated in Table 4. The environmental condition observed during the data collection session was a similar environmental condition typically experienced by all participants, during their other exercise and training sessions.

Table 4: Environmental condition across the 15m RSA sprint training

	Pre	During	Post	Average
Outdoor WBGT (ºC)	28.8	26.4	27.1	27.4
Ambient temperature (Ta)(ºC)	29.0	27.6	27.3	28.0
Relative humidity (RH)(%)	88.2	91.1	96.8	92.0
	31.9	28.3		28.9
Globe Temperature (Tg) (ºC)			26.6	

Discussion

Repeated sprint ability (RSA) as a popular method of training especially for speed and agility development among team sports athletes has only started to be quite popular recently. Although usage of similar methods existed for quite some time and known by most practitioners (coaches), it was not widely researched previously. It has been quite difficult to explore the characteristics and features of RSA, because of the spontaneity of player movements, as example during field-based team sports (Spencer et al. 2005).

Repeated sprint ability (RSA) training involves several tests including number of sprint repetitions sprint duration, duration, recovery, type of recovery, form of exercise and training status (Galvin, et., al., 2013; Spencer, Bishop, Dawson, & Goodman, 2005). However, RSA durations, number of sets, and recovery time are varied from one study to another. For instance, this research approached the mode of total 3 sets with 5 repetitions of 15m sprint for each set. The duration for rest in-between each repetition was at 60 seconds while rest in-between set was 5 minutes, referred to previous repeated sprint ability(RSA) training research (Girard et. al, 2011). Discussions in this section thus might not be able to be fully compared with other studies with different set-up and configurations. However, what will be discuss here will be highly correlates with the findings of the study and scientific base theory of it.

Hydration status level and changes in hydration status across the training

In this study, there were two different kinds of methods to assess the hydration status of the participants. Hydration status was assessed by measuring urine specific gravity (USG) using refractometer and strip. Based on the t test result for pre and post data, the refractometer result indicated 1.013 ± 0.010 for pre set 1and 1.013 ± 0.008 collected for post set 3. For the strip result, mean for pre set 1 is 1.012 ± 0.007 while mean for post set 3 showed 1.013± 0.008. From the results, it can be concluded that there were no significance changes that had been notified in hydration status among the participants across the RSA training session.

As indicated by Casa et. al (2000) in the indexes of hydration status for urine specific gravity, a person is well hydrated if the USG value is less than 1.010, minimal dehydration is in range of 1.010 – 1.020 while 1.021-1.030 is categorized as a significant dehydration. The worst state of hydration status level is when USG reading is more than 1.030, which it is categorized as in serious dehydration level. In this study, the participants` USG level was between 1.012-1.013. A comparison of these values to the guidelines of the National Athletic Trainers' Association suggests the participants were categorized in the minimal dehydration level (Casa et. al, 2000). This is however explained that participants were already experience slightly dehydrate prior to the training session.

The USG reading might as well linked to the environment and temperature on the time the data collection had been carried out. As the data was collected in the evening environment condition with average outdoor WBGT temperature was 27.4ºC and 92% relative humidity, it might appear to have an effect on the outcome. While the data collection was took place in the evening, the participants` hydration level might have been influenced by their activities throughout the day before they came to the RSA training session. Therefore, it can yield contradictory result which showed participants were already in a minimal dehydration level even since before the training session began. In this study, USG were collected in the evening, before and after the training session, might not be as accurate as USG reading on the first urine in the morning, as hydration status can be influenced by many factors.

Nevertheless, pre and post the 15m RSA sprint session's showed that there were no significant changes can be observed for both USG reading via refractometer as well as from the strip readings. However, the hydration level was maintained in minimal dehydration, with no alteration in hydration status detected towards the end of the training session. The USG result of this study were in agreement with the National Athletic Trainers" Association in their position statement for fluid replacements for athletes, which recommends that athletes should begin activity with a USG at or below 1.020 to ensure adequate hydration (Casa et. al,2000).

Conversely, the participants` body mass result showed a significant difference between pre and post RSA session, with a decrease in body weight measurement observed. The result was 63.21kg± 8.25 for pre set 1 and 62.97kg± 8.23 for post set 3. However, the percent body weight loss showed only 0.38± 0.14% of body mass loss overall. If the percent body mass loss are less than 1%, assumption can be made that participants were not dehydrated (Casa et.al., 2000). It is suggested that participants only in the state of mild hypohydration or would represent a normal variation of body mass on day to day basis.

Previous research stated that minimal percent of body weight loss that will started to compromosie body function or performance are between 1-2 % (Maughan, 2003; Armstrong et.al., 2012). Cheuvront, Carter & Sawka (2003) reported similar results where they stated that exercise performance decrement were only evident when the body mass loss is more than 2%. This view is supported by Cheuvront et. al (2004). Their study assessed 65 healthy men which underwent moderate intensity walking in the heat for 2-3 hours. Our findings was in agreement with their results which stated that the variability in body mass of 1.1% or less from the baseline was just an indication of daily water body turn-over or individual`s regular body mass deviation. Therefore, for this present study, a reduction of 0.38% of body mass, with a very small amount of water loss can be safely said as not an indication of further dehydration among the participants involved.

As a conclussion, participants began the 15m sprint training in a minimal hypohydration state, as indicated by USG and strip. The hydration level was maintained from initial towards the end of the training as no significance hydration changes was detected among the participants. It is also suggested that 0.38± 0.14% of body mass loss among the participants, which is less than1% body mass reduction from baseline, may just only lead to very mild hypohydration and do not appear to be associated with further dehydration levels.

Sprint time performance before and after RSA

Overall, results for mean sprint time indicated no significance differences across the training session. Albeit that, it somehow showed a slight trend of decrement in the sprint performance of the participants. As showed in the Table 2, mean sprint time for set 1 started with 6.69 ±0.07s and decrease to 6.61± 0.11s towards the end of set 3, however can demonstrate as a persistent state of sprint performance.

Explanation accounting for the nearly constant state of this sprint time may include that participants might gave all out sprinting in the initial phase with a burst and recover (rest in between) each repetition that can offer the participants to continuous anaerobic exercise. This suggested that participants were involved in a high energy exercise with low rest intervals between each repetitions and sets, which it might help out participants to sprint with the maximum capacity for the next repetition. Furthermore, the sprint time seem to be in a steady state, can be understandable as the shift of dominance energy system started to happen. With aerobics energy systems comes more into play, it is suggested that it helps the participants to have a more constant performance.

These present findings are comparable to a study by Thébault, Léger, and Passelergue (2011). Their research was on repeated sprint ability and aerobic fitness (n=19), in which their assessment involved the RSA test (3 sets of 5 40-m sprints with 1-minute rest between sprints and 1.5 minutes between sets). Their results showed that subjects with greater maximal aerobic speed competent to maintain almost constant level of speed across the RSA sets and repetition of repeated sprints and achieved better recovery between series. Another study by, Cheuvront et. al (2006) also explored the effects of hypohydration and moderate hyperthermia (core temperature elevation) on anaerobic exercise performance in a temperate environment. Their study involved a single 15-s Wingate anaerobic test (WAnT) which was used to assess anaerobic performance (peak power, mean power, and fatigue index). Their results indicated that there was no significant changes of the performance, neither moderate hydration group nor the moderate hyperthermia affected anaerobic exercise performance in a temperate environment.

In summary, the persistent state of the sprint time across the 15m RSA training session somehow could illustrate the participants` good combination of aerobic capacity (which is supported by aerobic metabolism in order that exercise can be performed for extended time) as well as anaerobic capacity (which is utmost stressed in high intensity activities but in short duration). Participants can cope well with the training methods in cumulative ways as in this case, participants were able to continually reproduce short burst of maximal sprint, repeatedly with short recovery period. It is suggested for further research, to explore the relationship of volume of oxygen maximum (VO_2max) for the aerobic capacity, along with anaerobic threshold or lactate threshold measurement during this type of repeated sprint ability training for more precision details.

Heart rate responses during a 15m RSA sprint training session

Heart rate response was one of the physiological changes that were evaluated during this 15m RSA sprint training session. Participants` heart rate was measured immediately after finishing of each set. The results for heart rate responses across the training yielded a significance increment. The heart rate response were identified to increase gradually from set 1 (122±9bpm) towards set 3 (144± 11bpm). Bonferoni post hoc via pairwise analysis revealed that mean heart rate for set 1 was significantly lower than set 2. Likewise, set 1 also showed a significantly lower than set 3.

This finding is in line with the results of a study by Cheuvront et. al (2005). Their study investigated hypohydration effects on endurance exercise performance in two conditions (temperate or cold air) using eight subjects. Their study found that heart rate was significantly higher at 30min within the temperate trial. Similar results obtained from a research by Gonzalez et. al (1999), where their study investigated the influence of body temperature on the development of fatigue during prolonged exercise in the heat. Their findings showed an increment in heart rate while stroke volume was observed to be reduced paralleled the rise in core temperature (36-40ºC).

Overall, present study indicated heart rate response significantly increased in a linear line, in proportion to the exercise intensity and duration, while performing the 15m RSA sprint training ($p<0.001$). As this sprint training session only involved 30 seconds of recovery time between each repetitions, and 5 minutes between each sets, the heart rate tend to rise incrementally across the training session and having peaks at the end of sets.

Blood Pressure during a 15m RSA sprint training session

As indicated in Table 2, significant differences observed between sets ($p=0.021$) in post-exercise systolic blood pressure level with lower post exercise reading. Diastolic blood pressure on the other hand was found to be fluctuated from start to end of the RSA session, with significant difference observed with minimal increment post exercise ($p=0.020$).

The post-exercise hypotension in which the systolic level was found to be significantly lower is an acceptable in normal condition, as studies have shown that immediately post-exercise, blood pressure level will be much lower than the reading recorded prior to exercise (Pescatello et. al, 1991; Syme et. al, 2006; de Salles et. al, 2010).

Initially, the assumption was that apart from normal regulatory effect for recovery after exercise, the lower blood pressure might also due to the effect of excess post-exercise oxygen consumption (EPOC). However, previous study has suggested that this is not the cause due to different time course of action (Williams et. al, 2005). Systolic blood pressure was an indicator of the blood flow in the arteries. The harder the exercise, the more blood will be delivered in the arteries, thus higher systolic blood pressure level. The diastolic blood pressure was an indicator of pressure in the arteries, when the heart was relaxed (after each pumping out). In order to allow more oxygen delivered to the whole body, the blood vessels will be more relaxed (for wider diameter, more blood flow). This resulted in the lower systolic level. Similar study on circuit based exercise also yields similar result (Paoli et. al, 2013).

In relation to this, the researcher based on above reasons suggested that participants involved in this study were basically active and possess a strong heart which can pump more blood with less effort. Since exercise is understood to reduce resistance in arteries, it consequences was that the blood flow more freely. Hence, if the heart can work less to pump blood for muscles and overall body used, the force on the arteries decreases and end with the lower blood pressure. This result advocate one of the benefits of this type of exercise is lower blood pressure level, which can be used as an anti-hypertensive exercise. Though, this requires further investigation.

Rate of perceived exertion (RPE) during a 15m RSA sprint training session

It's quite interesting to be noted that while both hydration status and sprint time performance were found to be insignificantly change during the three sets of RSA performed in this study, RPE measurements indicated otherwise.

This result is in line with other findings which demonstrated that ratings of perceived exertion were increased along with the exercise intensity or duration. A study by Cheuvront et. al (2005) compared the effect of hypohydration on endurance exercise performance in temperate and cold air environment, also demonstrated an increment of RPE over time of training. On the other hand, the consequence of physiological changes, as example the constriction of peripheral blood vessels to maintain blood pressure, decreased stroke volume, decreased in cardiac output and increased stroke volume may bring out a negative outcome on RPE. Moreover, a greater perception of exertion also can be lead by the decreased of plasma volume changes throughout the training session (Aldridge, Baker & Davies, 2005). As this may advise that the other physiological changes are basically connected to each other and may influence to the other responses to the body.

As RPE was measured based on verbal responses from the participants, it reflected the feelings, sensations and physical stress experienced by the participants during the protocol. If hydration status or heart rate (as indicated by the results) did not play the role in promoting the uneasiness experienced by the participants, another possible explanation might be purely be on psychological and muscle metabolism factors. However this was not measured in this study, and thus leaves the assumption to be verified in future studies. But for the discussions, other studies have shown that while level of fluid in the body were not significantly affected, blood lactate accumulation in the muscle may have increase the level of difficulty for the muscle to contract at a much faster rate (muscle buffer capacity) (Bishop, Edge, & Goodman, 2004), although participants had increased their physical effort. Previous study have shown that phosphagen system is the main energy system used during an RSA session performed by professional rugby rules players (elite athletes) (Wadley & Le Rossignol, 1998). Thus for participants which was not in elite category such as participants of this study, their energy source might be derived dominantly from both anaerobic energy system (phosphagen and glycolysis). Glycolysis produce blood lactate as their by-product (Gastin, 2001).

However, it must be noted that other activities, in addition to sprinting, may lead to fatigue during team-sport competition such as energy expenditure during eccentric contractions, change of direction movements and jogging or striding for extended periods could also contribute to fatigue (Spencer et. al, 2005). It is evident that the anaerobic ATP production during short-duration sprinting is provided by considerable contributions from both PCr degradation and anaerobic glycolysis, confirming the significance of glycolytic activity during this type of exercise. The importance of anaerobic glycolysis is supported by the fact that PCr stores are only partly depleted during short duration sprinting.(Spencer et. al, 2005).

In summary, RPE increased significantly across the training session. Nevertheless, it is evident that each of the variables which is exercise mode, sprint duration, sprint repetitions, recovery duration and type of recovery can significantly affect participant`s RPE as well as their performance.

Correlation between hydration status, sprint time, heart rate response, blood pressure and RPE

Based on the correlation result between hydration status and sprint time of the subjects, the data indicated high correlation with the value of $r= 0.967, p=0.012$. Based on present study hydration status data, the mean of urine specific gravity showed no changes across the test, which the value was 1.013 ± 0.01. It means that hydration level was maintained in the steady state (minimal dehydration) throughout the training session, while the sprint time showed almost constant with a slight of decrement of sprinting time.This finding is in line with the results of Morris et. al (1998) in their study to determine the effect of hot environment on performance of prolonged, intermittent, high intensity shuttle running. The results between the two trials of 12 active sportsmen showed a decrement in performance occurred although no differences were identified in the level of dehydration, rating of perceived exertion, blood glucose and lactate, plasma free fatty acid and ammonia concentrations. Furthermore, , Baker et. al (2007) who observed among the basketball player, stated that a progressively greater decline in basketball playing ability as dehydration progressed from 1 to 4%.

This significant high correlation observed, which hydration status affect the sprint performance might be due to fatigue and accumulation of lactic acid in the body. This is supported by the RPE data which showed the RPE increase from 4 ± 2 at the beginning and 6 ± 2 at the finishing. This showed that the subjects were fatigue towards to the end of the test. Girard, Mendez-Villanueva and Bishop (Girard et. al, 2011) in their review had found similar pattern in many studies related to RSA and fatigue using both laboratory and field based assessment

In spite of this, non significance relationship between hydration status and heart rate found in this study, implying that levels of dehydration among the participant did not affect heart rate to increase in the training session. As participants` hydration level was maintained in minimal dehydration level throughout the training session, therefore it seems that hydration status do not turn out to become a factor to impair heart rate response. This finding was in contrary with what has been found in another study on hydration by Carter et. al, 2005. Their participants demonstrated heart rate response was influenced by dehydration ($3.9 \pm 0.7\%$ body weight loss), and it was ended with reduction of overall heart rate response after exercise in the heat. But again, current finding indicated only ‘mild dehydration’; with the environment temperature can be said as ‘normal’ to the participants, which was used to play sports in the similar set-up and environmental condition involved.

In term of relationship between hydration status and blood pressure, as far as the knowledge of the researcher, no study has been found investigating blood pressure responses during an RSA session in relation to hydration status. This study recorded no significance relationship evident between hydration status and blood pressure during RSA session. However other studies that investigate blood pressure responses from other types of exercise in the heat indicated that blood pressure declined parallel with dehydration (González-Alonso, Calbet and Nielsen, 1998; Gonzalez-Alonso, Mora-Rodriguez and Coyle, 2000). Research by González-Alonso, Calbet and Nielsen (1998) investigated whether any reduction occurred on the blood flow to exercising muscles when cardiac output and systemic vascular conductance decline with dehydration during prolonged exercise in the heat. Their study was conducted on seven euhydrated, endurance-trained cyclists performed two trials of cycling to exhaustion at 35ºC. Their findings concluded that due to the decrement in perfusion pressure and systemic blood flow, blood flow to the exercising muscle declined significantly with dehydration. Hence, one explanation of our no significance relationship between hydration status and blood pressure might be related to the static hydration level. Nevertheless, the constant hydration level in minimal dehydration level did influence the post exercise blood pressure to be lower than pre exercise blood pressure.

To conclude, the present results suggest that the ability to repeat the sprints were still tolerable among the participants. Therefore, increase in the mode and loading parameters of this repeated sprint ability training can be suggested or applied in the future (such as shorten time of recovery, increase the sets and repetitions involved/intensity).

For future studies and implementation, coaches or researchers involved is suggested to also monitor or assess blood lactate accumulation during the RSA session. It is a more precise and reliable parameter to validate the physiological responses to exertion in response to the training session involved.

As no hydration changes were observed across the training session, the result might be different if urine specific gravity can be obtained from the first urine in the morning. This will allowed identification of the actual hydration state of the participants before beginning the testing session. It will control the cofounding factor as the hydration level can be fluctuating throughout the day. Future studies should take this into consideration.

It is also can be concluded that repeated shuttle sprints might be an effective training practice for improving the heart rate responses, apart from their actual purpose of developing speed and agility. The practical implications of these findings also suggest anti-hypertensive exercise as it might help to lower the blood pressure. Nevertheless, these require further studies for more improvement and to scrutinise on all suggestion for better outcome.

References

1. Aerenhouts, D., Zinzen, E., & Clarys, P. (2011). Energy expenditure and habitual physical activities in adolescent sprint athletes. *Journal of Sports Science & Medicine*, *10*(2), 362.
2. Aldridge, G., Baker, J. S., & Davies, B. (2005). Effects of hydration status on aerobic performance for a group of male university rugby players. *Journal of Exercise Physiology Online*, *8*(5), 36-42.
3. Aloui, A., Chaouachi, A., Chtourou, H., Wong, D. P., Haddad, M., Chamari, K., et al. (2012). Effects of Ramadan on the diurnal variations of repeated sprints performances. *International Journal of Sports Physiology and Performance*, *8*(3), 254-263.
4. Armstrong, L., Maresh, C., Castellani, J., Bergeron, M., Kenefick, R., LaGasse, K., et al. (1994). Urinary indices of hydration status. *International Journal of Sport Nutrition, 4*(3), 265.
5. Armstrong, L. E. (2007). Assessing hydration status: The elusive gold standard. *Journal of the American College of Nutrition, 26*(5 Suppl), 575S-584S.
6. Armstrong, L. E., Ganio, M. S., Casa, D. J., Lee, E. C., McDermott, B. P., Klau, J. F., ... & Lieberman, H. R. (2012). Mild dehydration affects mood in healthy young women. *The Journal of nutrition*, *142*(2), 382-388.
7. Astorino, T. A., Allen, R. P., Roberson, D. W., Jurancich, M., Lewis, R., & McCarthy, K. (2012). Attenuated RPE and leg pain in response to short-term high-intensity interval training. *Physiology & Behavior, 105*(2), 402-407.
8. Baker, L. B., Dougherty, K. A., Chow, M., & Kenney, W. L. (2007). Progressive dehydration causes a progressive decline in basketball skill performance. *Medicine and science in sports and exercise, 39*(7), 1114-1123.
9. Benardot, D. (2006). *Advanced sports nutrition*. Champaign: IL: Human Kinetics.
10. Bishop, D., Edge, J., & Goodman, C. (2004). Muscle buffer capacity and aerobic fitness are associated with repeated-sprint ability in women. *European Journal of Applied Physiology, 92*(4-5), 540-547.
11. Bishop, D., Girard, O., & Mendez-Villanueva, A. (2011). Repeated-sprint ability - part II: recommendations for training. *Sports Medicine, 41*(9), 741-756.
12. Borg, G. (1998). *Borg's perceived exertion and pain scales*. New York: Human kinetics.
13. Boutcher, S. H. (2010). High-intensity intermittent exercise and fat loss. *Journal of Obesity*, *2011*.
14. Bowtell, J. L., Cooke, K., Turner, R., Mileva, K. N., & Sumners, D. P. (2013). Acute physiological and performance responses to repeated sprints in varying degrees of hypoxia. *Journal of Science and Medicine in Sport*.
15. Buchheit, M., Abbiss, C. R., Peiffer, J. J., & Laursen, P. B. (2012). Performance and physiological responses during a sprint interval training session: relationships with muscle oxygenation and pulmonary oxygen uptake kinetics. *European Journal of Applied Physiology, 112*(2), 767-779.
16. Buchheit, M., Bishop, D., Haydar, B., Nakamura, F., & Ahmaidi, S. (2010). Physiological responses to shuttle repeated-sprint running. *International Journal of Sports Medicine, 31*(6), 402-409.
17. Casa, D. J., Armstrong, L. E., Hillman, S. K., Montain, S. J., Reiff, R. V., Rich, B. S., et al. (2000). National Athletic Trainers' association position statement: Fluid replacement for athletes. *Journal of Athletic Training, 35*(2), 212-224.

18. Carter III, R., Cheuvront, S. N., Wray, D. W., Kolka, M. A., Stephenson, L. A., & Sawka, M. N. (2005). The influence of hydration status on heart rate variability after exercise heat stress. *Journal of Thermal Biology, 30*(7), 495-502
19. Chen, M. J., Fan, X., & Moe, S. T. (2002). Criterion-related validity of the Borg ratings of perceived exertion scale in healthy individuals: a meta-analysis. *Journal of Sports Sciences, 20*(11), 873-899.
20. Cheuvront, S. N., Carter III, R., Castellani, J. W., & Sawka, M. N. (2005). Hypohydration impairs endurance exercise performance in temperate but not cold air. *Journal of Applied Physiology, 99*(5), 1972-1976
21. Cheuvront, S. N., Carter, R. I. I. I., Montain, S. J., & Sawka, M. N. (2004). Daily body mass variability and stability in active men undergoing exercise-heat stress. *International journal of sport nutrition and exercise metabolism, 14,* 532-540
22. Cheuvront, S. N., Carter, R., 3rd, Haymes, E. M., & Sawka, M. N. (2006). No effect of moderate hypohydration or hyperthermia on anaerobic exercise performance. *Medicine and Science in Sports and Exercise, 38*(6), 1093-1097.
23. Coutts, A. J., Rampinini, E., Marcora, S. M., Castagna, C., & Impellizzeri, F. M. (2009). Heart rate and blood lactate correlates of perceived exertion during small-sided soccer games. *Journal of Science and Medicine in Sport, 12*(1), 79-84.
24. De Salles, B. F., Maior, A. S., Polito, M., Novaes, J., Alexander, J., Rhea, M., & Simão, R. (2010). Influence of rest interval lengths on hypotensive response after strength training sessions performed by older men. *The Journal of Strength & Conditioning Research, 24*(11), 3049-3054
25. Dirckx, J. H. (2001). The synthetic genitive in medical eponyms: is it doomed to extinction. *Panace, 2*(5), 15-24.
26. Galloway, S., & Maughan, R. J. (1997). Effects of ambient temperature on the capacity to perform prolonged cycle exercise in man. *Medicine and Science in Sports and Exercise, 29*(9), 1240-1249.
27. Gastin, P. B. (2001). Energy system interaction and relative contribution during maximal exercise. *Sports Medicine, 31*(10), 725-741.
28. Galvin, H. M., Cooke, K., Sumners, D. P., Mileva, K. N., & Bowtell, J. L. (2013). Repeated sprint training in normobaric hypoxia. *British journal of sports medicine, 47*(Suppl 1), i74-i79.
29. Girard, O., Mendez-Villanueva, A., & Bishop, D. (2011). Repeated-sprint ability - part I: factors contributing to fatigue. *Sports Medicine, 41*(8), 673-694.
30. Gonzalez-Alonso, J., Calbet, J. A., & Nielsen, B. (1998). Muscle blood flow is reduced with dehydration during prolonged exercise in humans. *Journal of Physiology, 513*(Pt 3), 895-905.
31. Gonzalez-Alonso, J., Calbet, J. A., & Nielsen, B. (1999). Metabolic and thermodynamic responses to dehydration-induced reductions in muscle blood flow in exercising humans. *The Journal of Physiology, 520* (2), 577-589.
32. Gonzalez-Alonso, J., Mora-Rodriguez, R., & Coyle, E. F. (2000). Stroke volume during exercise: interaction of environment and hydration. *American Journal of Physiology- Heart and Circulatory Physiology, 278*(2), H321-330.
33. Groepenhoff, H., Westerhof, N., Jacobs, W., Boonstra, A., Postmus, P. E., & Vonk-Noordegraaf, A. (2010). Exercise stroke volume and heart rate response differ in right and left heart failure. *European Journal of Heart Failure, 12*(7), 716-720.
34. Guyton, A. C., & Hall, J. E. (2000). *Textbook of mecidal physiology*. St. Louis:MO W. B. Saunders Company.
35. Hammouda, O., Chtourou, H., Chahed, H., Ferchichi, S., Kallel, C., Miled, A., et al. (2011). Diurnal Variations of Plasma Homocysteine, Total Antioxidant Status, and Biological Markers of Muscle Injury During Repeated Sprint: Effect on Performance and Muscle Fatigue-A Pilot Study. *Chronobiology International, 28*(10), 958-967.
36. Heaps, C., Gonzalez-Alonso, J., & Coyle, E. (1994). Hypohydration causes cardiovascular drift without reducing blood volume. *International Journal of Sports Medicine, 15*(02), 74-79.
37. Heydari, M., & Boutcher, S. H. (2013). Rating of perceived exertion after 12 weeks of high intensity, intermittent sprinting. *Perceptual & Motor Skills, 116*(1), 340-351.
38. Hunter, G. R., Fisher, G., Bryan, D. R., & Zuckerman, P. A. (2012). Weight loss and exercise training effect on oxygen uptake and heart rate response to locomotion. *Journal of Strength and Conditioning Research, 26*(5), 1366.
39. Ingebrigtsen, J., Bendiksen, M., Randers, M. B., Castagna, C., Krustrup, P., & Holtermann, A. (2012). Yo-Yo IR2 testing of elite and sub-elite soccer players: Performance, heart rate response and correlations to other interval tests. *Journal of Sports Sciences, 30*(13), 1337-1345.
40. Judelson, D. A., Maresh, C. M., Farrell, M. J., Yamamoto, L. M., Armstrong, L. E., Kraemer, W. J., et al. (2007). Effect of hydration state on strength, power, and resistance exercise performance. *Medicine and Science in Sports and Exercise, 39*(10), 1817-1824.

41. Katz, A. (2001). *Physiology of the Heart*. Philadelphia: USA: Wolters Kluwer Health.
42. Kraft, J. A., Green, J. M., Bishop, P. A., Richardson, M. T., Neggers, Y. H., & Leeper, J. D. (2010). Impact of dehydration on a full body resistance exercise protocol. *European Journal of Applied Physiology, 109*(2), 259-267.
43. Lane, R. D., McRae, K., Reiman, E. M., Chen, K., Ahern, G. L., & Thayer, J. F. (2009). Neural correlates of heart rate variability during emotion. *NeuroImage, 44*(1), 213-222.
44. Lentner, C. (1981). *Geigy scientific tables* (8th ed.). Delhi: Ciba-Geigy Limited.
45. McGarvey, J., Thompson, J., Hanna, C., Noakes, T. D., Stewart, J., & Speedy, D. (2010). Sensitivity and specificity of clinical signs for assessment of dehydration in endurance athletes. *British Journal of Sports Medicine*, *44*(10), 716-719.
46. Maughan, R. J. (2003). Impact of mild dehydration on wellness and on exercise performance. *European Journal of Clinical Nutrition*, *57*, S19-S23.
47. Murray, B. (2007). Hydration and physical performance. *Journal of the American College of Nutrition, 26*(5 Suppl), 542S-548S.
48. G. Morris, J., Nevill, M. E., Lakomy, H. K. A., Nicholas, C., & Williams, C. (1998). Effect of a hot environment on performance of prolonged, intermittent, high-intensity shuttle running. *Journal of Sports Sciences*, *16*(7), 677-686.
49. Nybo, L., Sundstrup, E., Jakobsen, M. D., Mohr, M., Hornstrup, T., Simonsen, L., et al. (2010). High-intensity training versus traditional exercise interventions for promoting health. *Medicine and Science in Sports and Exercise, 42*(10), 1951-1958.
50. Oppliger, R. A., & Bartok, C. (2002). Hydration testing of athletes. *Sports Medicine, 32*(15), 959-971.
51. Paoli, A., Pacelli, Q.F., Moro, T., Marcolin, G., Neri, M., Battaglia, G., Sergi, G., Bolzetta, F. & Bianco, A., 2013. Effects of high-intensity circuit training, low-intensity circuit training and endurance training on blood pressure and lipoproteins in middle-aged overweight men. *Lipids Health Dis,* 12**,** 131
52. Pescatello, L. S., Fargo, A. E., Leach, C. N., & Scherzer, H. H. (1991). Short-term effect of dynamic exercise on arterial blood pressure. *Circulation, 83*(5), 1557-1561
53. Rakobowchuk, M., Harris, E., Taylor, A., Cubbon, R. M., & Birch, K. M. (2013). Moderate and heavy metabolic stress interval training improve arterial stiffness and heart rate dynamics in humans. *European Journal of Applied Physiology*, 1-11.
54. Ross, D. L., & Neely, A. E. (1983). *Textbook of Urinalysis and Body Fluids*: Appleton-Century-Crofts Norwalk, CT.
55. Rynders, C., Angadi, S., Weltman, N., Gaesser, G., & Weltman, A. (2011). Oxygen uptake and ratings of perceived exertion at the lactate threshold and maximal fat oxidation rate in untrained adults. *European Journal of Applied Physiology, 111*(9), 2063-2068.
56. Sawka, M. N. (1992). Physiological consequences of hypohydration: exercise performance and thermoregulation. *Medicine and Science in Sports and Exercise, 24*(6), 657.
57. Sawka, M. N., Burke, L. M., Eichner, E. R., Maughan, R. J., Montain, S. J., & Stachenfeld, N. S. (2007). American College of Sports Medicine position stand. Exercise and fluid replacement. *Medicine and Science in Sports and Exercise, 39*(2), 377-390.
58. Sawka, M. N., & Coyle, E. F. (1999). Influence of body water and blood volume on thermoregulation and exercise performance in the heat. *Exercise Sport Science Review, 27,* 167-218.
59. Shirreffs, S. M. (2000). Markers of hydration status. *Journal of Sports Medicine and Physical Fitness, 40*(1), 80-84.
60. Shirreffs, S. M. (2009). Conference on "Multidisciplinary approaches to nutritional problems". Symposium on "Performance, exercise and health". Hydration, fluids and performance. *Proceedings of the Nutrition Society, 68*(1), 17-22.
61. Spencer, M., Bishop, D., Dawson, B., & Goodman, C. (2005). Physiological and metabolic responses of repeated-sprint activities. *Sports Medicine*, *35*(12), 1025-1044.
62. Syme, A. N., Blanchard, B. E., Guidry, M. A., Taylor, A. W., VanHeest, J. L., Hasson, S., ... & Pescatello, L. S. (2006). Peak systolic blood pressure on a graded maximal exercise test and the blood pressure response to an acute bout of submaximal exercise. *The American Journal of Cardiology, 98*(7), 938-943.
63. Thayer, J. F., Ahs, F., Fredrikson, M., Sollers III, J. J., & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health. *Neuroscience & Biobehavioral Reviews, 36*(2), 747-756.
64. Thébault, N., Léger, L. A., & Passelergue, P. (2011). Repeated-sprint ability and aerobic fitness. *The Journal of Strength & Conditioning Research*, *25*(10), 2857-2865
65. Tortora, G. J., Grabowski, S. R., Tortora, G. J., & Roesh, B. (1996). *Principles of Anatomy and Physiology* (8th ed.). Hoboken; NJ: Wiley.
66. Vidal Andreato, L., Franzoi de Moraes, S. M., Del Conti Esteves, J. V., Regina de Araujo Pereira, R., Lopes de Moraes Gomes, T., Vidal Andreato, T., et al. (2012). Physiological responses and rate of perceived exertion in

Brazilian jiu-jitsu athletes. *Kineziologija*, *44*(2), 173-181.
67. Wadley, G., & Le Rossignol, P. (1998). The relationship between repeated sprint ability and the aerobic and anaerobic energy systems. *Journal of Science and Medicine in Sport*, *1*(2), 100-110.
68. Watson, G., Judelson, D. A., Armstrong, L. E., Yeargin, S. W., Casa, D. J., & Maresh, C. M. (2005). Influence of diuretic-induced dehydration on competitive sprint and power performance. *Medicine and Science in Sports Exercise*, *37*(7), 1168-1174.
69. Williams, J. T., Pricher, M. P., & Halliwill, J. R. (2005). Is postexercise hypotension related to excess postexercise oxygen consumption through changes in leg blood flow?. *Journal of Applied Physiology*, *98*(4), 1463-1468.
70. Yaicharoen, P., Wallman, K., Morton, A., & Bishop, D. (2012). The effect of warm-up on intermittent sprint performance and selected thermoregulatory parameters. *Journal of Science and Medicine in Sport, 15*(5), 451-456.

✉ Raiza Sham Hamezah
Faculty of Sports Science & Coaching, Sultan Idris Education University
Email: raiza.sham@yahoo.com