EFFECTS OF EXERCISE INTENSITY AND STIMULUS SPEED ON COINCIDENCE ANTICIPATION TIMING WITH RESPECT TO GENDER IN ADOLESCENT BADMINTON PLAYERS

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ABSTRACT

EFFECTS OF EXERCISE INTENSITY AND STIMULUS SPEED ON COINCIDENCE ANTICIPATION TIMING WITH RESPECT TO GENDER IN ADOLESCENT BADMINTON PLAYERS

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Purpose of this study was to investigate the effects of exercise intensity and stimulus speed on Coincidence Anticipation Timing (CAT) performance with respect to gender in adolescent badminton players. Forty one male (n = 20) and female (n = 21) competitive badminton players (aged 11-17 years old) voluntarily participated to this study after ethical approval. CAT performance was measured by Bassin Anticipation Timer at 1mph (low) and 5 mph (high) stimulus speeds using an incremental running protocol under three exercise intensities (rest condition, 70%, & 90% Heart Rate Reserve). Raw scores were transformed into Absolute Constant Error and Variable Error indicating accuracy and variability, respectively. A number of mixed model ANOVAs indicated that males were more accurate in comparison to females across all exercise intensities at low (1 mph) stimulus speed, but not at fast (5 mph) speed. The results also showed that males were more accurate and consistent than females at low (1 mph) stimulus speed in comparison with high (5 mph) speed at rest condition. Additionally, males had more accurate and consistent CAT performances for both stimulus speeds at high exercise intensity. Finally, all participants were more accurate and consistent at high (5 mph) stimulus speed in comparison with low (1 mph) speed at moderate exercise intensity while regardless of gender of the participants.

Keywords: coincidence anticipation timing, gender, exercise intensity, stimulus speed

ÖZ

CİNSİYETE BAĞLI OLARAK GENÇ BADMİNTON OYUNCULARINDA EGZERSİZ ŞİDDETİ VE UYARI HIZININ SEZİNLEME ZAMANINA ETKİSİ

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Bu çalışmanın amacı, genç badminton oyuncularında egzersiz şiddeti ve uyarı hızının "Zamansal Sezinleme Süresi" (ZSS) performansı üzerindeki etkisini, cinsiyete göre incelemektir. Bunun için yaşları 11 ve 17 arasında olan gönüllü 21 kız ve 20 erkek badminton oyuncusu etik kurulu onayından sonra bu çalışmaya katılmışlardır. ZSS performansı şiddeti artan bir koşu protokolü aracılığıyla üç farklı egzersiz şiddeti (dinlenik, % 70 ve % 90 Kalp Atışı Rezervinde) ve iki farklı uyarı hızında 1 mph (düşük) ve 5 mph (yüksek) Bassin Sezinleme Zamanlayıcısı kullanılarak ölçülmüştür. Veriler "Mutlak Sabit Hata" ve "Değişken Hata" olarak doğruluk ve tutarlık göstergesi olarak kullanılmıştır. Tekrarlanan ölçümlerde varyans analizi sonuçları, erkeklerin üç egzersiz şiddeti durumunda ve düşük (1 mph) uyarı hızında, kızlara göre daha doğru ZSS performanslarının olduğunu göstermiştir. Cinsiyetler açısından yüksek uyarı hızında anlamlı fark bulunamamıştır. Ayrıca dinlenik durumda ve düşük uyarı hızında erkekler daha doğru ve tutarlı performans göstermiştir.

Bunlara ek olarak yüksek şiddetli egzersizde ve her iki uyarı hızında erkeklerin daha doğru ve tutarlı olduklarını göstermiştir. Son olarak orta şiddetli egzersiz durumunda cinsiyet ayrımı yapmamak sızın yapılan analiz sonuçlarına göre genç badminton oyuncularının düşük uyarı hızına kıyasla yüksek uyarı hızında daha doğru ve tutarlık sezinleme performanslarına sahip olduğunu göstermiştir.

Anahtar Kelimeler: sezinleme zamanını, cinsiyet, egzersiz şiddeti, uyarı hızı

“ To the World Full of ***RESPECT*** & ***PEACE*** ”

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LIST OF ABBREVIATION OF THE TERMS

CAT	Coincidence Anticipation Timing
CTA	Coincidence Timing Accuracy
BAT	Bassin Anticipation Timer
HRR	Heart Rate Reserve
HR_{Rest}	Resting Heart Rate
HR_{Max}	Maximum Heart Rate
HR_{peak}	Peak Heart Rate
$\|CE\|$	Absolute Constant Error
VE	Variable Error

CHAPTER I

INTRODUCTION

The present chapter includes eight sub-sections. Firstly, the background of the study will be expressed at the beginning of the chapter. Secondly, the rationale of the study will be presented. Then, research questions will be pointed out followed by the purpose of the study, research hypotheses, research limitations, and significance of the study. Finally, definitions of the terms will be explained in order to avoid misunderstandings during reading.

1.1 Background of the Study

To a certain extent, good performance of motor behaviour and high level of perceptual abilities are needed in almost all of sports especially those requiring interceptive actions (i.e. catching, hitting, & striking) to proficiently execute motor skills (Mori, Ohtani, & Imanaka, 2002; Ak & Koçak, 2010; Akpinar, Devrilmez, & Kirazci, 2012). Most of the fast ball and racket sport players are expected to intercept, catch, or hit the ball at the right position and time to send it to the intended location of the opponent's field and finally to be successful in the area of expertise. Actually, the direction of the ball relies on its contact position and timing of the stroke. More precisely, sportsmen and sportswomen should have the ability and capability to precisely predict the direction and speed of the approaching ball to judge about the exact target in space in order to hit or intercept at the desired location (Williams, Davids, Burwitz, & Williams, 1994).

Coincidence anticipation timing (CAT) is one of the most controversial daily-living facets among the concepts of the cognitive performance. Actually, making fast responses (i.e. reaction time) as well as interceptive actions (i.e. catching & hitting) needs using accurate anticipation. The underlying capability of forecasting the right final arrival place of a stimulus or moving object in time and space in order to coordinate a proper response with respect to that temporal information and arrival time is known as coincidence anticipation timing ability (Abernethy & Wood, 2001; Lyons, Al-Nakeeb, & Nevill, 2008; Sanders, 2011; Duncan, Smith, Hankey, & Bryant, 2014; Duncan, Stanley, Smith, Price, & Wright, 2015). Poulton (1957; as cited in Lyons et al., 2008, p. 206) explained coincidence anticipation (sometimes as coincidence timing) as making of interception actions (catching, hitting, & striking) and classified into two parts; receptor anticipation (the ability of making decision about the time interval that external event occurred) and effector anticipation (the ability of making decision about the time interval that takes a person to move his/her limbs as a response).

Poulton (1957) also believed that coincidence anticipation is the division of anticipation or types of anticipation. Anticipation is also divided into three parts as perceptual anticipation; spatial anticipation (refers to where an event will happen), and temporal anticipation (refers to when an event will happen), and event anticipation (refers to what will happen). Depending on the situation, perceptual anticipation includes one or whole of anticipations (McMorris, 2004).

According to Lobjois, Benguigui, and Bertsch (2006) coincidence anticipation timing includes two components of perceptual (determination of the moving object at the target in space) and perceptuomotor (coordination of motor response to approaching object) processes. Based on Poulton's (1957) classification of receptor and effector anticipation, Fleury and Bard (1985) indicated that accurate coincidence-anticipation must include the completion of three phases; the first one is a sensory phase where the stimulus and its characteristics are detected to correct and guide motor actions. The second one is a sensory-motor integration phase during which, the exact place and time of the arriving object are determined and response is planned. Finally, a response is completed at the third phase known as execution or motor phase (Meeuwsen, Goode, & Goggin, 1997; Al-Nakeeb, Lyons, & Nevill, 2005; Lyons et al., 2008; Duncan, Smith, & Lyons, 2013).

Coincidence anticipation timing ability (response accuracy) should be assessed by the discrepancy in time interval between arrival of the oncoming object at the target and the performer's response execution (Ak & Koçak, 2010). But here the question is how should coincidence anticipation be evaluated? The accuracy of CAT performances have been generally evaluated by Bassin Anticipation Timer (BAT) device in many studies (Lyons et al., 2008; Akpinar et al., 2012; Duncan et al., 2013; Kim, Nauhaus, Glazek, Young, & Lin, 2013). This apparatus, in general, consists of a control console, a response switch, and one or more sequential runways with a linear series of movement-simulating LED lights or diode lamps. When the lamps are illuminated in series, participants are required to press the response switch when they anticipate the last lamp will illuminate.

Kim and colleagues (2013) indicated that catching and intercepting a moving object are abilities based on different perceptuo-motor processes of coincidence anticipation timing. Adapting our actions to the environmental restrictions or responses to the approaching moving objects with interceptive actions (i.e., catching, throwing, & hitting) even in daily life, for example, crossing a busy road as a pedestrian or driving a vehicle on a street are all the simple instances of coincidence anticipation timing performance (Lobjois, Benguigui, & Bertsch, 2005, 2006). Additionally, Sanders (2011) believed that people anticipate even when kissing each other, shaking hands, pick up a cup or doing other daily routines.

The predicting capacity of an oncoming ball or approaching objects seem to be a fundamental concept in execution and response in sport activities where environment is inconsistent and unpredictable during action (open skills). Also, it is indicated that coincidence anticipation timing ability is important in sports consist of uncertainty that the control of the movement skill is not determined by the performer but by the environment (externally-paced) such as receiving a pass in football or receiving a serve in tennis (Singer, Cauraugh, Chen, Steinberg, & Frehlich, 1996; Duncan et al., 2013). Therefore, anticipation is one of the most important factors in terms of open skills' execution in externally-paced sports (Williams, Katene, & Fleming, 2002).

In the sport world, coincidence anticipation timing has been widely conducted in order to test the athletes' hand-eye coordination and the prediction of it on visual accuracy in terms of talent identification and the selection of gifted individuals (Ripoll & Latiri, 1997). The athletes should keep in mind that the accurate and successful coincidence anticipation timing performance depends on the anticipation of moving object in exact time, proper body movements toward the object, and the position of the object while response has been completed. Otherwise, biased or incorrect perception of moving object could result in temporal error (Meeuwsen, et al., 1997). In other words, delay and a small modification or inaccuracy in anticipation may lead to lose a score in sports (Ak & Koçak, 2010).

Todays, researchers have used an enormous number of methods to explore coincidence anticipation timing in order to make significant improvements in our understanding of this topic regarding different aspects. Accordingly, a large number of investigations examined the effect of several areas, for instances, sex difference, skill levels (expert-novice differences), age, exercise intensity and fatigue on CAT in sport activities. Coincidence anticipation timing ability could be improved or deteriorated by some variables and factors. It has been shown that the combination of maturational (age) and experiential factors (experience) may affect perceptuo-motor processes (Benguigui & Ripoll, 1998).

There are also some prior investigations claiming that there is a big enhancement on coincidence anticipation by sports practice and it may improve continuously with age (Ak

& Koçak, 2010; Akpinar et al., 2012) until approximately 11 years of age (Ripoll & Latiri, 1997). It is also noted that athletes of open skills (e.g. football, basketball, and volleyball) were more accurate and less variable than closed skills' athletes (e.g. running and track and field) as well as non-athletes, only at the faster speeds (5.36 and 6.71 m/s vs. 2.68 and 4.02 m/s) on bassin timer device (Benguigui & Ripoll, 1998). In spite of these efforts in the literature, there are still some unanswered questions related to these subjects. Shim, Carlton, Chow, and Chae (2005) debated that the criticism on CAT in the scientific literature is due to the experimental procedures (e.g., nature of the responses) conducted on the majority of prior investigations or the elimination of the interrelationship between perception and response in some researches.

A large number of factors differentiate athletes and sport players from expert to novice. Investigators stated that skilled players could be able to demonstrate high level of perceptual abilities, technical and tactical expertise, cognitive expertise, and decision-making. Moreover, some believed that experts generally have greater dynamic visual acuity than novices. In the case of coincidence anticipation timing, experts also anticipate more quickly, accurately, and precisely rather than less-skilled players (Lyons et al., 2008). Clearly, this ability could distinguish expert and novice players, as highlighted beforehand (Ishigaki & Miyao, 1993). In other words, we can conclude that coincidence anticipation timing is one of the absolutely essential perceptual skills requiring enhancement by the athletes to be an elite player.

One of the externally-paced sports including open skills is badminton where there is a fast changes of the shuttlecock and rapid body movements. Badminton is a non-contact competitive racket sport played with high intensity by either two players (singles) or two teams (doubles) opposing each other which requires a wide variety of rapid limb movements to induce quick changes at different positions on a court. Badminton is a game that consists of several techniques and tactics which require some fundamental skills such as jumps, lunges needed to be done with high speed, agility and power. Hong, Wang, Lam, and Cheung (2014) were of the opinion that footwork is the most important skill required in this racket sport, however, badminton players do need both physical and mental fitness factors. According to Badminton World Federation (BWF), playing area in the badminton court shaped with side boundary lines (44 feet/13.4 meter length) and back boundary lines (20 feet/6.1 meter width) which are parallel to the net (http://www.bwfbadminton.org).

Considering the distance between baselines in the badminton court (approximately 13 meters) and the average speed of the shuttlecock which is measured as 35 mph (125 km/hr) in adults match, after the opponent hits the shuttlecock, there is just nearly half a second for the player to respond back the return shot (Chen, Pan, & Chen, 2009; Akpinar et al., 2012). Thus, according to the importance of the short reply time, tracking and precise anticipation of the direction and speed of the shuttlecock would play a key role to perform the best shot (which needs visual accuracy). Otherwise, biased or incorrect perception of moving object or a small change or mistake in anticipation may result in temporal error (Meeuwsen et al., 1997; Ak & Koçak, 2010).

1.2 Rationale of the Study

Nowadays, it has been proved that to skilfully execute motor skills in almost all of externally-paced sports including open skills (e.g. football and basketball) in which precise coincidence anticipation timing performs a main role to intercept, catch, and hit a ball, there is a great demand for high level of perceptual abilities. To date, a huge enhancement have been occurred in our knowledge and understanding of coincidence anticipation timing from a large number of researches have been conducted on this topic in terms of different areas such as gender differences, experience and practice.

A myriad of ball-playing sports require the fastest and the most accurate anticipation to predict the possible place of a ball in space or on the ground because it is crucial to be successful in preparing of suitable response. For instance, imagine a badminton player, tracking and anticipating the direction and speed of shuttlecock movement may result in predicting an exact place of shuttlecock in order to be in a right position and hitting an appropriate return shot (Akpinar et al., 2012). It is plain that coincidence anticipation timing is the most essential ability for all athletes who practice with a ball/shuttlecock in sports such as badminton, table tennis, football, volleyball and etc.

In the review by Sanders (2011), it was indicated that there was a low number of empirical data which inspecting the impact of gender on coincidence anticipation timing as well as understanding of sport specificity in the scientific literature. Speaking about sex differences, although Sanders put forward that males generally had better performance on coincidence anticipation tasks than females, there were still numerous ambiguous studies as well as null findings on coincidence-anticipation in terms of gender impacts.

On the other hand, investigators have conducted a low number of studies discovering gender differences on coincidence anticipation timing in children and adolescents in comparison with adults (Sanders, 2011). Thus, there is likely to be a great gap of this issue in the literature and it seems to be that selecting gender difference of adolescents would be a plausible variable into our study due to the lack of researches have been conducted on this topic of this nature.

Present study is an extended version of previous investigations conducted by Lyons et al. (2008) and Duncan et al. (2013) in which they researched the impacts of rest condition, moderate and high exercise intensities on coincidence anticipation timing tasks with respect to skill level and stimulus speed, respectively. The philosophy of current thesis was formed based on these investigations. However, gender differences on coincidence anticipation timing in physical exertion conditions have not been studied more in the literature. Hence, the main aim of this study was to explore the effect of gender on CAT task with respect to different exercise intensities and stimulus speeds.

1.3 Purpose of the Study

This study is an attempt to address the effects of exercise intensity and stimulus speed on coincidence anticipation timing task with respect to gender.

1.4 Research Questions

The followings are the research questions which were formed with regard to the purpose of the study.

Exercise intensity and gender

i. Is there a significant interaction between exercise intensity and gender on CAT at *1 mph stimulus speed*?
ii. Is there a significant difference between male and female badminton players in three different exercise intensities on CAT at *1 mph stimulus speed*?
iii. Is there a significant interaction between exercise intensity and gender on CAT at *5 mph stimulus speed*?
iv. Is there a significant difference between male and female badminton players in three different exercise intensities on CAT at *5 mph stimulus speed*?

Stimulus speed and gender

v. Is there a significant interaction between stimulus speed and gender on CAT at *rest condition*?

vi. Is there a significant difference between male and female badminton players at two different stimulus speeds on CAT in *rest condition*?

vii. Is there a significant interaction between stimulus speed and gender on CAT at *moderate exercise intensity*?

viii. Is there a significant difference between male and female badminton players at two different stimulus speeds on CAT in *moderate exercise intensity*?

ix. Is there a significant interaction between stimulus speed and gender on CAT at *high exercise intensity*?

x. Is there a significant difference between male and female badminton players at two different stimulus speeds on CAT in *high exercise intensity*?

Intensity and stimulus speed

xi. Is there a significant interaction between exercise intensity and stimulus speed on CAT?

xii. Is there a significant difference between exercise intensity and stimulus speed on CAT?

1.5 Research Hypotheses

The hypotheses of this thesis were formed with regard to the research questions which as follows:

Exercise intensity and gender

I. Whit regard to exercise intensity and gender at 1 mph stimulus speed:

   i. There is no interaction between exercise intensity and gender on CAT at *1 mph stimulus speed*.

   ii. Exercise intensity does not have any significant effect on CAT in both male and female badminton players at *1 mph stimulus speed*.

II. Whit regard to exercise intensity and gender at 5 mph stimulus speed:

   i. There is no interaction between exercise intensity and gender on CAT at *5 mph stimulus speed*.

   ii. Exercise intensity does not have any significant effect on CAT in both male and female badminton players at *5 mph stimulus speed*.

Stimulus Speed and Gender

III. Whit regard to stimulus speed and gender at rest condition:

   i. There is no interaction between stimulus speed and gender on CAT at *rest condition*.

   ii. Stimulus speed does not have any significant effect on CAT in both male and female badminton players at *rest condition*.

IV. Whit regard to stimulus speed and gender at moderate exercise intensity:

   i. There is no interaction between stimulus speed and gender on CAT at *moderate exercise intensity*.

   ii. Stimulus speed does not have any significant effect on CAT in both male and female badminton players at *moderate exercise intensity*.

V. Whit regard to stimulus speed and gender at high exercise intensity:

   i. There is no interaction between stimulus speed and gender on CAT at *high exercise intensity*.

ii. Stimulus speed does not have any significant effect on CAT in both male and female badminton players at *high exercise intensity*.

Exercise Intensity and Stimulus Speed

VI. Whit regard to exercise intensity and stimulus speed:

i. There is no interaction between exercise intensity and stimulus speed on CAT.

ii. Exercise intensity and stimulus speed do not have significant effects on CAT in badminton players.

1.6 Research Limitations

The present study is limited to age and participants of badminton. Assessing the coincidence anticipation timing ability of male and female badminton players between the ages of 11 to 17 years old, restricted the concept of the study to limited age and just badminton in the field of racket sport.

1.7 Significance of the Study

At recent decades, a large number of researchers have conducted numerous studies in the field of coincidence anticipation timing with respect to a number of variables such as gender and age differences, exercise intensity and fatigue, stimulus speeds and the like. Recently, it has been showed that there is a gap in empirical data with regard to gender differences on coincidence anticipation. Although some investigations indicated that males generally had better performance on coincidence anticipation tasks than females, there are still some ambiguous and unanswered questions in terms of gender impacts on coincidence anticipation timing. In addition, sanders (2011) was of the opinion that researchers have carried out a number of studies assessing CAT ability of adults more than children. Hence, there is likely to be a great gap of this issue in the literature.

In line with previous studies which have been carried out the effect of exercise intensity on coincidence anticipation timing issue with respect to skill level (Lyons et al., 2008) and different stimulus speeds (Duncan et al., 2013) and also paying attention to a low number of conducted researches on CAT regarding gender differences especially between children and adolescents, on which the main philosophy of this dissertation was based. This is all the more reason why discovering the effects of exercise intensity and stimulus speed on CAT with respect to gender of adolescent badminton players seemed to have benefit for improving our understanding and knowledge of coincidence anticipation timing at different conditions.

The same method of assessing coincidence anticipation timing under several exercise intensities increases the similarity between present study and referred researches' findings. If outcomes are similar to those of studies, therefore, the findings achieved will be unique and trustworthy due to the similar nature of measuring CAT ability.

As far as other researches' findings are concerned, coincidence anticipation timing performances be affected by exercise intensity and stimulus speed. However, Lyons et al. (2008) believed that exercise intensity had no effect on CAT. On the contrary, some studies indicated that high exercise intensity deteriorate CAT performances as well as high stimulus speed. Therefore, it is assumed that the findings of present study indicated a deterioration under high exercise intensity at high stimulus speed on CAT.

1.8 Definitions of the Terms

The mentioned definition of the terms were used throughout the present dissertation as follows:

Coincidence Anticipation Timing (CAT): "is the ability to predict the arrival of a moving object at a particular point in space and coordinate a movement response with that arrival" (Lyons, 2011, p.52).

Bassin Anticipation Timer (BAT): Coincidence anticipation timing ability has been typically measured by this apparatus (Sanders, 2011).

Heart Rate Reserve (HRR): Is the difference between resting hear rate (i.e., is the lowest number of a person's heart beats per minute at rest condition; HR_{rest}) and maximum heart rate (i.e., is the highest number of a person's heart beats per minute during maximum physical exertion; HR_{max}) and utilised in the determination of exercise heart rates. This method is often referred to as the Karvonen method (Thompson, Bushman, Desch, & Kravitz, 2010, p. 372).

Badminton Players: Whole participants of this thesis, attended badminton training three days a week for at least three years and they were regularly engaged in national competitive badminton activities.

Absolute Constant Error (|CE|): Represents the bias of a group's performance when signed scores cancel each other out (Ripoll & Latiri, 1997).

Variable error (VE): The participant's standard deviation around his or her mean constant error which represents the consistency (variability) of responses (Baurès, Oberfeld, & Hecht, 2010).

CHAPTER II

LITERATURE REVIEW

The effects of exercise intensity and stimulus speed on coincidence anticipation timing with respect to gender were examined at present dissertation. For better understanding the prior findings of core concept and regarding the aim of the current study, present chapter highlights the impacts of several factors which could affect coincidence anticipation timing performance in daily life or sport events. This chapter includes six parts. First subtitle is about measuring coincidence anticipation timing. In the other parts of literature review, the effects of skill level and sport specificity, age, gender, exercise intensity and fatigue, and stimulus speed on coincidence anticipation timing were expressed.

2.1 Coincidence Anticipation Timing Measurement

Coincidence anticipation timing ability is the capability of anticipating the right arrival time and place of a moving stimulus in order to coordinate a proper motor response with respect to that arrival time. Coincidence anticipation timing has been widely used to test hand-eye coordination in order to select gifted athletes (Akpinar et al., 2012) and this measurement has been typically done by bassin anticipation timer device conducted in approximately 29 previous researches (Sanders, 2011).

Bassin anticipation timer apparatus consists of a control console, a response switch, and one or more sequential runways with a linear series of movement-simulating LED lights. When the lamps are illuminated in series, participants are required to press the response switch when they anticipate the last lamp will illuminate (Kim et al., 2013). Early responses show with negative and late responses with positive sign in direction as well.

In terms of measuring error scores, three main error scores have been usually wondered in the experiments including coincidence anticipation timing task. The accuracy of coincidence anticipation timing scores measured by absolute error (AE) and constant error (CE), whereas, variable error (VE) show the variability/inconsistency of the CAT scores. In the literature, there is generally a lower amount of CE for males showing that they were more accurate than females in comparison with AE and VE. In other words, the better CAT performance occurred for females were rare in a way that whenever it happens, this favour females in CE.

2.2 Effects of Skill Level and Sport Specificity on CAT

The majority of investigations have been examined skill-oriented differences in coincidence anticipation timing during the last two decades (Williams, Davids, & Williams, 1999, p. 97). Nevertheless, many researchers believed that there is a great lack of experiments examining the effect of skill level and sport specificity within the scientific literature. Although studies addressing the effect of experiential factors illustrated that elite athletes can perform much more accurately than novices in terms of CAT tasks, there are some conflicting results in the current scientific literature. Some researchers believed that skilled athletes were more accurate and less variable than novices. However, others indicated that there were no significant differences between expert and novice athletes (Benguigui & Ripoll, 1998; Lyons et al., 2008).

Akpinar et al. (2012) were of the opinion that the outcomes from the variety of researches of coincidence anticipation timing conducted on the skill levels showed that, generally, experts are more accurate and less variable than novices on CAT tasks. Other Studies have also claimed that high-skilled players have a greater CAT ability in reactive sports (e.g., basketball, baseball, and tennis) which require proper interceptive actions (i.e., striking, catching, and hitting) than less-skilled players (http://www.d.umn.edu). Benguigui and Ripoll (1998) also supported the previous outcomes that skilled athletes are more accurate than less skilled individuals on CAT only if the characteristics of the moving stimulus are exactly similar to that faced within the sport area of expertise. Delignières, Brisswalter, and Legros (1994) debated that the superiority of experts over novices in performance may result from additional resource investment.

In general, elite players could be able to demonstrate high level of technical and tactical expertise, cognitive expertise, decision-making, visual search, and perceptual abilities which differentiate elite ones from novices (Lyons et al., 2008). Experts and athletes have also faster reaction time than novices and non-athletes, respectively (Ak & Koçak, 2010). Actually, the accuracy of coincidence anticipation timing performances separates expert and novice individuals. Unsurprisingly, athletes with high level of CAT ability could be able to judge the final place and time of the approaching object in space in order to be ready at the right position to manage a response towards the opponent at the designated target. Consequently, we can conclude that coincidence anticipation timing is one of the most important skills requiring enhancement by the athletes to be an elite player.

In line with some prior studies, Akpinar and colleagues (2012) researched the coincidence anticipation timing accuracy and consistency between three racket sports (tennis, table tennis, and badminton) within three different stimulus speeds (1 mph, 3 mph, and 5 mph defined as low, moderate, and high) using bassin anticipation timer device. For this purpose, 15 girls and 15 boys participated for each sport branch (the total number of 90 participants).

The results of this research showed that there was a significant interaction between stimulus speed and racket sports in both absolute and variable errors. The results of between-group analysis revealed that tennis players indicated lower accuracy and consistency than badminton and table tennis players at the low stimulus speed (1 mph). Whereas, badminton players indicated lower accuracy than tennis and table tennis players at the moderate stimulus speed (3 mph). Also, badminton players had lower coincidence anticipation timing consistency than tennis players, but no difference was found between badminton and table tennis players at this stimulus speed (3 mph). Finally, table tennis players indicated lower accuracy and consistency than badminton and tennis players at the high stimulus speed (5 mph). In conclusion, the authors highlighted that players from racket sports (i.e., tennis, badminton, and table tennis) require different visual and motor systems in CAT abilities as well as the amount of time for return shot with respect to the distance between two players in a court/table and speed of the ball/shuttlecock.

In the research by Lyons and colleagues (2008), the main purposes were to determine the effect of different exercise intensities (rest, moderate-, and high- intensity exercise) on coincidence anticipation timing as well as looking at the differences between novice and expert Gaelic games players (hurlers) in terms of post-exercise justifications on coincidence anticipation timing. For this purpose, 11 senior hurlers from Ireland championship (expert) and 9 junior standard hurlers (novice) were recruited. Bassin anticipation timer was used as an assessment device of CAT ability at rest, moderate- (70% HRR), and high- (90% HRR) intensity exercise with constant stimulus speed of 5 mph. To reach the steady-state of mentioned heart rate reserve (70% and 90% HRR) of participants, exercise intensities were set with an incremental running protocol on a motorized treadmill. As a real-world task to simulate hitting a ball, participants made continuous swing with a standard hurley through a photoelectric beam of bassin timer instead of pushing switch button. Whole testing orders were counterbalanced and each participant was tested immediately after each exercise intensity by recording 20 anticipation trials. Raw scores were expressed as constant error

(CE), absolute error (AE), and log variable error and analysed by separate repeated-measures Analysis of Variance. The results of absolute error and log variable error indicated that the expert hurlers executed significantly better CAT performances than novice players at all exercise intensities. Within-group analyses were also analysed on the expert and novice hurlers with no significant difference in the experts' CAT performances within all exercise intensities. Whereas, within-group analysis on the novices depicted that there was significant difference between rest condition and moderate exercise intensity. Lyons et al. (2008) concluded that elite hurlers could maintain the ability of CAT at all exercise intensities, whereas, novice hurlers could do the best CAT performances at moderate intensity as well.

In 1997, Ripoll and Latiri researched the effect of expertise and practice in expert and novice table tennis players on coincident timing task. Expert group (playing table tennis for more than 10 years) consists of eight males from the French National Team and other eight males participated in the experiment as a novice group (had no table tennis playing background or very occasionally). Participants were examined through two conditions with constant speed and constant deceleration. The results indicated that there was no practice effect under constant speed but there was an effect of expertise under deceleration condition. This means that expert players were more accurate than novices in the decelerated condition. In addition, the results confirmed that the experts were less trajectory dependent than novices. In conclusion, the findings demonstrated that there is merely specific visual information processing characteristic that differentiate experts from novices and not just due to practice.

Lyons, Al-Nakeeb, Hankey, and Nevill (2013) studied the effects of rest condition and differential exercise intensities (moderate & high) on the accuracy of tennis groundstroke between expert and novice players. There were a number of hypotheses proposed in their study, for instance, there is a decline in groundstroke accuracy between expert and non-expert players or there is consistent trends in performance of male and female players across three experimental conditions. Two groups of expert (thirteen players; 7 males & 6 females) and novice (seventeen players; 13 males & 4 females) tennis players were recruited for this study. In terms of measuring the accuracy of groundstroke of participants and also inducing 70% peak heart rate (HR_{peak}) as moderate and 90% HR_{peak} as high exercise intensities, the modified version of the Loughborough Tennis Skills Test (mLTST) was used. The results from a number of mixed model ANOVAs indicated that there was a highly significant difference between groundstroke accuracy at rest compared to high exercise intensity as well as moderate-intensity in comparison with high exercise intensity. The results also revealed that there was a highly significant main effect for fatigue, however, there was no significant interaction for fatigue and expertise in terms of accuracy of the scores. Speaking about the consistency of the data, similar to accuracy, there was a significant fatigue main effect and there was no fatigue and expertise interaction. In conclusion, the authors claimed that the accuracy of tennis groundstroke had little deterioration under moderate exercise intensity in comparison with rest condition. Nonetheless, there was a great decline between expert and novice players at high exercise intensity. Not surprisingly, expert players had more accurate and consistent shots across all experimental conditions.

2.3 Effect of Age on CAT

Age is one of the most important factors on coincidence anticipation timing. Although the issue of anticipation have extensively been examined in the several areas, the study of age differences is a relatively new and recent area of interest in the field of timing of motor actions. This is all the more reason why there is no sufficient explanation to demonstrate how or why these differences are observed.

A majority of studies have been conducted on the physiological and psychomotor aspects of increasing age showing a significant decrease in reaction time and tracking. Lobjois et al.

(2005, 2006) debated that older adults especially over 60 years old have much more difficulty to adapt their body response against the displacement of a moving object or environmental constraints. Therefore, they execute coincidence anticipation timing tasks with a great deal of errors.

On the one hand, coincidence anticipation timing performance could be improved by the amount of practice and age (Ripoll & Latiri, 1997; Benguigui & Ripoll, 1998; Ak & Koçak, 2010). Similarly, according to Söğüt, Ak, and Koçak (2009) performing a precise anticipation timing depends on some factors such as practice and age which could improve the CAT ability. However, strong evidence from numerous perceptu-motor studies confirmed that information processing and reaction time of older adults were affected negatively by age.

On the other hand, Meeuwsen, Goode, and Goggin (1997) also debated that coincidence anticipation timing ability could deteriorate with age. To support this, they researched the effects of age, type of tasks on motor demands, and stimulus speed on the accuracy and consistency of coincidence anticipation timing task in young and older females. The participants were 20 females (10 young female students and 10 older females). Bassin anticipation timer device was used to evaluate CAT measures using two types of tasks (pressing button and hitting) and three different stimulus speeds of 4, 8, and 12 mph indicated as slow, medium, and fast speeds with counterbalanced order. The raw error scores (constant error, absolute error, variable error, absolute constant error) were assumed as the dependent variables. The results indicated less absolute and variable errors for younger females when they performed switch-press task across all the stimulus speeds. Nevertheless, in the hitting task, the variability of performances considerably increased with stimulus speed suggesting that unlike response bias, the variability of response was closely depended on stimulus speed. The results also showed that older participants had similar response bias with the young females in switch-press task but not in the hitting task and the variability response reduced as stimulus speed increased in both tasks. In conclusion, it is understood that young and older females' perceptual systems were differently affected by manipulations of the task demand and stimulus speed.

Williams (1985) believed that coincidence anticipation timing would be improved in the duration of childhood. Benguigui and Ripoll (1998) debated that CAT ability would be mainly enhanced in children at the ages between 5 to 11 years old. Similarly, in the study by Bard, Fleury, Carriere, and Bellec (1981) it was shown that the coincidence anticipation accuracy improves in children ages 5-11 years. To support these findings, Kim et al. (2013) stated that CAT ability seems to be well-developed in the children at age 11. However Akpinar et al. (2012) were of the opinion that coincidence anticipation timing ability improves continuously with age. On the other hand, some investigators were of the opinion that the main improvement on coincidence anticipation was at ages of 7 and 10 years old (Williams et al., 2002).

Some studies (Benguigui & Reipoll, 1998; Willimas et al., 2002) stated that older players are more accurate and have more precise performances on coincidence anticipation timing tasks. Supportively, the study conducted by Söğüt et al. (2009) stated that 10-year-old tennis players had significantly lower CAT scores than 8 year-old and also had better performances than 9 year-old players.

One of the earliest investigations to determine the effect of age on the ability of coincidence anticipation timing was figured out by Williams (1985). This study consists of two experiments. In the first part, it was tried to explain age-related differences in response accuracy on a coincidence anticipation tasks. For this aim, 42 right-handed boys were placed into three 5-, 7-, and 9-year-old groups (n = 14 per group). As the fourth group, 14 male adults were recruited from a university. For the assessment of coincidence anticipation timing accuracy, the bassin anticipation timer device was used. The raw scores were expressed as three dependent measures (constant error, absolute error, and arm movement time). Six different stimulus speeds (1.5 mph, 2.0 mph, 2.5 mph, 3.0 mph, 3.5 mph, and 4.0 mph) were set and a total number of 60 test trials were recorded from each subject. The results indicated that the accuracy of 5-year-old boys were different and this group had larger errors compared to other three groups at the speed of 1.5 mph. In addition, 7-year-old group had less accurate CAT scores than 9-year-old and adult groups. Analysis also showed that at the speed of 2.0 mph, only 5-year-old and adult groups differed in their CAT accuracy. At high speeds (stimuli traveled from 2.0 to 4.0 mph) older subjects (9-year-old and adult group) had much more accurate CAT scores than younger children (5- and 7-year-old groups). The results of this study proved the outcomes of researches had been previously conducted on CAT which indicated that younger participants responded early at slow stimulus speeds, whereas, older participants and adults had better performances. To put in a nutshell, younger participants had early responses at slow and too late responses at fast stimulus speeds, however, they had most accurate CAT performances at intermediate speed of stimulus (2.5 and 3 mph). Older participants and adult group were also more accurate than the others at slow (1.5 and 2 mph) to intermediate (2.5 and 3 mph) stimulus speeds. There was a similar point between younger and older participants which they deteriorated CAT performances as stimulus speeds increased.

In line with previous study by Williams (1985) which indicated that there is a slight difference between younger (9 year-old) and adult participants, Kim and colleagues (2013) researched whether there were age, target location, and stimulus speed impacts on coincidence anticipation timing ability in simulated catching task. For this purpose, total number of 59 male participants with age 11 through 18 years who regularly participated in sports including coincidence anticipation timing (such as baseball, football, & basketball) for at least two years were recruited. The participants were distributed in three age groups; the first one was 11 to 13 years old group (n=22), the second group was 14 to 16 years old (n = 22), and 17 to 18 years (n = 15) as the third group. Bassin anticipation timer was utilised to set the four stimulus speeds (7.60, 8.49, 9.83, or 12.07 m/sec.$^{-1.}$). The runway of the apparatus was positioned in a way that participants could clearly recognise the oncoming stimuli light whether it approaches at the head or chest (with an angle of 10 degrees). The CAT scores were transferred into six error scores (constant error, absolute error, variable error, movement onset time, movement time, & movement speed). The analyses of age depicted that there were no significant differences in constant error, absolute error, movement onset times, and movement times across all age groups. In terms of the consistency of CAT scores, it is understood that older participants had less variable error than their younger counterparts. The results of this study taken also showed that the consistency of CAT scores enhanced with increasing age. Finally, the authors concluded that there was no significant difference in CAT task including simulated catching a high-speed in males aged between 11 to 18 years old.

In the study by Benguigui and Ripoll (1998) the development of perceptuo-motor processes of coincidence anticipation timing accuracy were examined with respect to maturational (i.e. age) and experiential (tennis practice) factors at three different motions (constant speed, acceleration speed, and deceleration speed). Participants (24 tennis players and 24 novices) were placed into four groups consisted of 7, 10, 13, and 23 years old. The results of this study revealed an improvement on a coincidence timing accuracy (CTA) between the age of 7 and 10 years old. The findings also showed that the accelerated or decelerated speed of trajectory had no impact on coincidence timing accuracy of whole tested groups. In contrast, Ripoll and Latiri (1997) found that table tennis players had more precise coincidence anticipation performances than novices on similar CAT task to this study only at decelerated trajectory. Finally, the results of this study suggests that very slight differences were between the 13- and 23-year-old tennis players and novices indicated that the development of coincidence timing accuracy is accelerated by tennis practice amongst the younger children.

It has been shown that age (maturational factor) may affect perceptuo-motor processes and the accuracy in coincidence timing actions can be improved by age (Benguigui & Ripoll, 1998). In the study conducted by Meeuwsen and colleagues (1997), it is suggested that manipulations of the task and characteristics of the stimulus may affect perceptual and motor systems of old females and also found that young female adults poorly execute CAT tasks than male adults.

Fleury and Bard (1985) examined the participants' coincidence anticipation timing performance by throwing a tennis ball standing 3 meters far from the target (0.5 × 0.5 meter) and synchronising the contact position of the ball with arriving of the light stimulus along the runway. Authors also claimed that except execution phase, the responsibility for precise coincidence anticipation timing performance in throwing task in their research is for sensory and sensory-motor integration phases. Results depicted that females had more temporal and spatial errors than males due to the complexity of response and increased stimulus speed, however, the data did not explain age impacts as the reason for spatial and temporal accuracy errors. Also, generalising the findings of age impacts on coincidence anticipation are of restricted value due to the oldest individual with age of 52 years old.

2.4 Effect of Gender on CAT

On the other side of the literature, gender difference is the other factor which may affect coincidence anticipation timing. In fact, not many researches have been carried out on this topic in the current literature. The importance of investigating potential gender differences is imperative in the literature. Because, knowing sex differences make cognitive abilities and also brain functioning to be better understandable in terms of neuropsychological development as well as appropriate educational programs. Few investigators found that there are some potential differences in coincidence anticipation timing performance between males and females.

There have been a majority of investigations that researched gender differences on coincidence anticipation timing in the laboratory by utilising bassin anticipation timer. The number of studies have been conducted on coincidence anticipation timing using this apparatus (switch-press) are more than real-world tasks. Generally, underestimation and overestimation of CAT measures are investigated in the studies of this nature. The outcomes from the studies of coincidence-anticipation indicated an evidence that there was an advantage for males in coincidence anticipation timing task which gradually becomes visible in all children, adolescents, and adults. Searching the possible reason for this advantages of males in coincidence anticipation showed that this would result from biological origin instead of sociocultural ones (Sanders, 2011).

Published studies from late 1970s investigating gender differences on coincidence anticipation timing skills reported many strong evidences of male advantages on the basis of cognitive abilities (Schiff & Oldak, 1990; Sanders, 2011). Nonetheless, there were some other researchers found different results indicating that females had better coincidence anticipation timing performance than males or there were no sex differences.

Considering coincidence anticipation timing ability, there were numerous papers which investigated the effect of different exercise intensities merely on the performance of male participants since 1979. McGlynn, Laughlin, and Rowe (1979) claimed that on the one hand, response may vary at several exercise intensities from males to females, but on the other hand, it may not differ. As a consequence, it seems to be obvious that there is a great need to study the effect of exercise intensity on females as well. In the literature review of present study, a minority of studies have been found which investigated the impact of exercise intensity on CAT tasks with respect to gender in spite of its importance (Duncan et al., 2013).

Dorfman (1977) examined the development of coincidence anticipation timing of 120 males and 120 females with the age range of 6 up to 19 years old which were divided into 6 age groups. For this experiment, participants were told to use a slide control to horizontally move a cursor to intercept a vertically moved stimulus while target was remain visible or disappeared before the arrival. The results developed the claim that males were more accurate and less variable than females when the stimulus remains visible. While, the author reported that there was no any significant difference in all error scores (AE, CE, & VE) when target was invisible before the arrival.

In line with Dorfman's study, Dunham (1997) studied the impacts of gender, age, stimulus speed, and practice on coincidence anticipation timing between 84 male and female elementary school students which were equally grouped by age from 7 to 12 years, consecutively. In the test session, the participants were expected to lift their foot off the switch while they see the moving ball about to reach to the target flag. The findings indicated that male students had more accurate scores than females but the variability difference was not reported.

To support the consensus of male advantage, Bard et al. (1981) measured the accuracy of coincidence anticipation timing of 144 children (6-11 years old). For this purpose, they designed three test sessions measuring coincidence anticipation timing accuracy with throwing on a target, assessing coincidence anticipation timing with simple and complex motor response tasks. The results of this study depicted that boys were more accurate (more temporal accuracy) and less variable (more spatial accuracy) than girls on coincidence anticipation tasks.

In addition to previous studies, Wrisberg and Mead (1983) tested sixty 6- to 8-year-old children using bassin anticipation timer on coincidence anticipation and arm movement response. Data from their study indicated that males had better coincidence anticipation timing performances than females just at fast training on absolute error. Whereas, females outperformed their male counterparts at slow training session on AE. All the other error scores showed no significant difference.

Along similar lines, Fleury and Bard (1985) researched coincidence anticipation ability of 102 males and 84 females with simple (button-press) and complex (throwing ball) tasks. The results were partly similar to the previous studies which reported a male advantage. The authors concluded that males accurately anticipated in the complex and simple-complex tasks in comparison with females, but not at simple task.

In 2011, Sanders said that knowing these cognitive ability differences are very important which can help understanding the concept of neuropsychological development. Sanders and Sinclair (2011) stated that, on average, females tend to outperform males on some verbal tasks whereas males generally outperform females on some spatial tasks (which classified into spatial perception, mental rotation, and spatial visualization). Consequently, there is a male advantage for coincidence anticipation timing performance over female (that emerges in children, adolescents and adults) in the literature.

Speaking about sex differences, although Sanders (2011) and other researchers put forward that males generally had better performance on coincidence anticipation tasks than females, conflicting results and no consensus were observed by previous studies. Similarly, some other investigators (Williams et al., 2002; Söğüt et al., 2009; Sanders, 2011) reported that, in general, male performers execute accurately and less variable with fewer error than female counterparts on CAT tasks. Conversely, others (Wrisberg & Mead, 1983; Petrakis; 1985;

Ripoll & Latiri, 1997) stated that there is no significant gender impact on CAT ability due to gender differences.

Söğüt and colleagues (2009) found more precise coincidence anticipation timing performance for males over their female counterparts. The authors researched the effects of gender and age on coincidence anticipation of junior tennis players. For this purpose, competitive junior tennis players (118 male and 110 female) aged 8, 9, and 10 years old were participated. Bassin anticipation timer was utilised to measure the accuracy of CAT scores. The results revealed that male players had more accurate CAT performances compared to females.

To support the findings of previous studies, it was found that young female adults poorly execute coincidence anticipation timing tasks than male adults (Meeuwsen et al., 1997). Actually, Sanders (2011) believed that there was a possibility that male advantage may be of biological and not due to sociocultural origins. However, the others were of the opinion that the more accurate CAT performances reported for males is because of differences in motor factors and spatiotemporal skills (Schiff & Oldak, 1990) or also sport involvements (Petrakis, 1985).

Ak and Koçak (2010) compared coincidence anticipation timing and reaction time of tennis and table tennis players (aged between 10 to 14) with respect to possible gender differences in their study. The relationship between playing background and the accuracy of both coincidence anticipation timing and reaction time (dependent variables) were also tested. Briefly, the main aim of this research was to evaluate coincidence anticipation accuracy by sex differences and sports' specificity. For this purpose, 107 tennis (55 female and 52 male) and 101 table tennis (42 female and 59 male) players recruited from different sport clubs in Ankara-Turkey. Participants were given 30 CAT trials. The presentation of stimulus speed was constant at 2 mph. The results revealed statistically significant main effects for both gender and sport indicating that males and tennis players had better mean coincidence anticipation timing accuracy that females and table tennis players, respectively. Hence, the results supported the authors' hypotheses related to CAT performance that tennis and male players had more accurate performance with less error on coincidence anticipation timing than table tennis and female players, respectively.

2.5 Effect of Exercise Intensity and Fatigue on CAT

The idea that exercise intensity or fatigue is a psychomotor (Lyons et al., 2008) and physiological (Duncan et al., 2013) stressor is well-established in the scientific literature. To date, a large part of the researches in terms of exercise intensity impact on coincidence anticipation timing tasks explored by Fleury, Bard, and colleagues in Canada. Nonetheless, there is no specific empirical and theoretical explanations for the effect of fatigue or exercise intensity on CAT due to the low number of studies investigated on this issue. Although some researchers investigated the effects of physical exertion on CAT performances (Al-Nakeeb et al., 2005; Lyons et al., 2008; Duncan et al., 2013), there are still some unanswered questions and nowadays, there is no theoretical justification for the impact of exercise intensity on CAT.

Looking more closely into the effect of physical exertion on coincidence anticipation performance of cognitive tasks requiring anticipation could result in conflicting findings. Although some researches (Al-Nakeeb & Lyons, 2007) indicated that cognitive performances (decision-making & problem-solving ability) get better with steady-paced aerobic exercises, other researchers (Al-Nakeeb et al., 2005) believed that there is no enhancement on cognitive tasks following exercise intensities. On the other hand, Al-Nakeeb and Lyons (2007) believed that exercise intensity has limited impact on coincidence anticipation timing tasks. These equivocal results are partly due to the way of examining the cognitive performance on exercise cessation instead of during exercise (Lyons, Al-Nakeeb, & Nevill, 2006a, 2006b; Duncan et al., 2015). Consequently, to support one of these claims the findings of some investigations could be a proper evidence that moderate-intensity of aerobic exercises may have a positive effect on cognitive tasks in sports (especially those requiring decision-making and anticipation). However, this effect may be disappeared through high-exercise intensity.

In one of the most recent studies, Duncan, Smith, and Lyons (2013) examined the impact of exercise intensity at different stimulus speeds on coincidence anticipation timing. For this study, 11 male and 3 female Sport and Exercise Science students participated. Coincidence anticipation timing ability was assessed using BAT device under rest condition and two exercise intensities (70% HRR indicated as moderate, and 90% HRR indicated as high) at different stimulus speeds (3, 5, and 8 mph). Similar to the study conducted by Lyons and colleagues (2008), participants reached a steady-state of 70% and 90% HRR by running on a motorised treadmill (using an incremental running protocol). The exercise intensity orders and the appearance of stimulus speeds were all counterbalanced and randomised. The raw scores were transferred into three error measurements as constant error (CE), absolute error (AE), and variable error (VE). The authors concluded that stimulus speed interacts with the impact of exercise intensity on coincident anticipation. Results of this study also showed that at a stimulus speed of 3 mph, there were no significant differences between all exercise intensities.

Al-Nakeeb, Lyons, and Nevill (2005) researched the impacts of different levels of exercise intensities on coincidence anticipation of less- and high-skilled players. For this aim, eighteen experts of racket sports, ball games, and ice hockey voluntarily participated in their study. Players were distributed in two levels (low and high) with respect to their sport playing background and anticipation demands. The coincidence anticipation timing scores accuracy was examined using bassin anticipation timer device at three stimulus speeds (3, 5, and 7 mph) under rest and two different physical exertions body fatigue (moderate and high). The moderate (70% HRR) and high (90% HRR) fatigue conditions were induced by performing an incremental exercise protocol on a Concept 2 indoor rowing ergometer. Each participant was tested by 10 CAT trials under three experimental conditions at three different stimulus speeds (total of 90 trials). The testing order and presentation of stimulus were all counterbalanced. The raw scores were expressed as absolute error, constant error, and variable error in milliseconds. The outcomes indicated that there was no significant differences between rest and two fatigue conditions as well as skill levels in dependent variables (AE, CE, and VE). However, there were both significant trials and stimulus speed effects. Trial effect showed that CAT performances improved gradually due to recovery process following exercise fatigue. Also, the results depicted as the stimulus speed increased, CAT performances of players improved. The authors concluded that fatigue at moderate (70% HRR) and high (90% HRR) exercise intensities were likely to have no significant impact on CAT performances of less- and high-skilled players. All in all, present data seems to suggest that physical exertions had a limited effect on the cognitive aspects involved in the capacity to anticipate a moving target.

In other study investigated by Al-Nakeeb and Lyons (2007), the effects of different exercise intensities during performance of cognitive tasks (concentration, anticipation, and heart rate response) were examined. Participants were 20 physically-active adults and testing conditions were all counterbalanced. Bassin anticipation timer was applied in terms of measuring coincidence anticipation timing ability under the three experimental conditions at rest, moderate- (50% of maximal heart rate reserve), and high-exercise intensity (80% of maximal heart rate reserve). Intended exercise intensities were induced using an incremental protocol on a Cycle Ergometer estimating by both heart rate reserve (HRR) and rating of perceived exertion (RPE). Analysis indicated that there was no significant difference on CAT performance under the three levels of physical exertion (rest, moderate, and high exercise intensity). But, a significant difference in heart rate was observed before and during performance of the anticipation task. The authors concluded that exercise intensity has limited effect on CAT tasks.

2.6 Effect of Stimulus Speed on CAT

Among the many factors have been studied to affect coincidence anticipation timing tasks, the effect of stimulus speed factor is more likely to have the greatest impact on coincidence anticipation timing and big interest to researchers (http://www.d.umn.edu). A majority of investigators have compared coincidence of anticipation ability under different stimulus speeds which varied due to measuring procedure and apparatus utilised.

According to the previous studies, it has been showed that some factors such as age and stimulus speed (i.e., how long it takes the moving object to move) may negatively affect the coincidence anticipation timing ability of older adults. Duncan, Stanley, Smith, Price, and Wright (2015) examined coincidence anticipation timing ability of older adults at different stimulus speeds before (rest condition), during (9 & 18 minutes), and after (immediately following a 20-minute passive rest condition) an acute bout of walking. To investigate this facet of cognitive performance, the number of 16 habitually physically active older adults (9 males & 7 females) from the age of 60 to 76 years old participated. Two different stimulus speeds (3 & 8 mph) were used in the bassin anticipation timing device to test the CAT ability of participants. Exercise intensity (50% HRR) was induced by asking participants to walk for 20 minutes on a treadmill. The results would seem to indicate that at slow stimulus speed (3 mph), CAT performances were enhanced during (at both 9 & 18 minutes) and after exercise in comparison with rest condition. Nevertheless, at faster stimulus speed (8 mph), absolute and variable errors were significantly increased at 18 minutes during the exercise which resulted in a poorer CAT scores. It is concluded that CAT scores with less accuracy recorded during exercise at faster stimulus speed.

When the speed of the stimulus is variable, the anticipation of moving object seems to be much more difficult in comparison with constant speed. Also, it is accepted that a person does not pay attention to the information of acceleration or deceleration of moving stimulus (Benguigui & Ripoll, 1998). Generally, it seems to be an agreement between the numerous researchers that early anticipation will yield as a result of slow stimulus speed, while faster stimulus speed will result late anticipation.

In the study of Akpinar and colleagues (2012) as explained beforehand, they examined the coincidence anticipation timing accuracy of three racket sports players (tennis, badminton, and table tennis) under low, moderate, and high stimulus speeds (1, 3, and 5 mph). The results of within-groups analysis indicated that tennis players had significantly less absolute error and variable error at 1 mph stimulus speed (low) in comparison with 3 mph (moderate) and 5 mph (high) stimulus speeds. Nonetheless, badminton players had significantly less absolute error and variable error at 3 mph stimulus speed (moderate) in comparison with 1 mph (low) and 5 mph (high) stimulus speeds. Finally, table tennis players had significantly less absolute error and variable error at 5 mph stimulus speed (high) in comparison with 1 mph (low) and 3 mph (moderate) stimulus speeds.

Williams et al. (2002) conducted a study to research the effects of age, skill level, and gender (as between-group factors) on coincidence anticipation timing with respect to evaluation of practice over trials and stimulus speed (as within-group factors). In the first part of the experiment, two constant stimulus speeds (2.68 m/s as low speed, 5.36 m/s as high speed) were used in bassin anticipation timer device to measure the accuracy of tennis strokes in CAT task. In terms of the effects of stimulus speed and gender on CAT performance, the results showed that there was only a significant interaction between stimulus speed and gender on variable error indicating that male participants were more consistent than girls at low stimulus speed. Nevertheless, the results depicted no difference between genders at fast stimulus speed on variable error. Therefore, the findings of this study supported the fact that higher stimulus speed is associated with lower variable error.

CHAPTER III

MATERIALS AND METHOD

The purpose of this chapter is to present a perspective of the research methodology conducted in this thesis which is designed to examine the effects of exercise intensity and stimulus speed on coincidence anticipation timing of badminton players regarding gender. This chapter generally tended to briefly explain some basic parts consists of participants, apparatus, experimental design, and finally data analyses.

3.1 Participants

Forty one badminton players consist of 20 males and 21 females were recruited. As it was debated beforehand, coincidence anticipation timing performance would be enhanced in children at the age range of 5 to 11 years old (Benguigui & Ripoll, 1998) and the main improvement was at ages of 7 and 10 years (Williams et al., 2002; Ak & Koçak, 2010). Therefore, total numbers of 41 male and female adolescents were taken part in the test sessions after ethical approval (Appendix A). Their age were between 11 to 17 years old and they had been training badminton for at least three years at three times a week. They were also competitive badminton players who were competing in several national championships and competitions. The mean age of male and female players were 13.6 years (*SD* = 1.85) and 13.71 years (*SD* = 1.31), respectively.

3.2 Data Collection Instrument

A Bassin Anticipation Timer device (Lafayette Instrument Co., Model 35575) is used to measure coincidence anticipation timing accuracy of the participants which was tested and proved by Abernethy and Wood (2001) to be a valid assessment for comparing anticipation timing and sport performance for both males and females. In Addition, Nettleton and Smith (as cited in Akpinar et al., 2012, p. 584) and Ramella and Wiegand (1983) found that bassin anticipation timer was a reliable and useful apparatus to measure errors reduction at various stimulus speeds. Surprisingly, Kuhlman and Beitel (1992) confirmed that this apparatus is an effective training device to improve batting skill of softball players. This device is commonly used in the assessment of coincidence anticipation timing accuracy (Abernethy & Wood, 2001; Rodrigues, Vasconcelos, Barreiros, & Barbosa, 2009; Sanders, 2011; Rodrigues, Barbosa, Carita, Barreiros, & Vasconcelos, 2012).

Bassin anticipation timer apparatus consists of a control console, a response switch, and one or more sequential runways with a linear series of LED lights (49 lamps). Pushing button, participants were able to respond anticipating the illuminating of the target lamp. Speed was set by how rapidly the lights were turned on and off. Three sections of runway (2.24 m) facing the participant were used. The runway sections were mounted on the table 87 cm from the floor. The first lamp was a yellow warning-light and the last red one was the target light on the last runway. All the remaining lights were movement-simulating LEDs' which illuminated sequentially down the runway in a linear pattern and make the sense of coming moving stimulus (moving from left to right) toward participants. This is happened by the control console which was connected to the runway.

3.3 Data Collection Procedure

The current study was designed to investigate the effect of gender on coincidence anticipation timing under different exercise intensities at different stimulus speeds. Each participant completed three experimental conditions under: 1) rest condition at 1 and 5 mph stimulus speeds; 2) moderate exercise intensity at 1 and 5 mph stimulus speeds; 3) high exercise intensity at 1 and 5 mph stimulus speeds. In parts, this study is an attempt to extend the findings by Lyons et al. (2008) and Duncan et al. (2013) in which they have tried to explain the impact of exercise intensity on coincidence anticipation timing tasks with respect to different stimulus speeds (3, 5, & 8 mph) or expertise (novice or expert), respectively.

Considering the nature of badminton (fast-ball & high intensity sport), coincidence anticipation timing was measured under three different exercise intensities (rest, moderate, & high) at two different stimulus speeds (1 & 5 mph) in order to investigate the individual differences between male and female badminton players.

Speaking about ethical procedure, the proposal of the present study was sent to the Human Research Ethical Committee at Middle East Technical University (METU). The permission of ethical committee was needed to show that the test instrument and data collection sessions were all without spiritual or physical threats. Plus, parent consent forms (Appendix B) were distributed one week before the test sessions. After the completion of consent forms by parents, they gathered and kept in a safe place.

Similar to the study by Duncan et al. (2013), the selection of exercise intensity and presentation of stimulus speeds were all counterbalanced (Appendix C). For this matter, all 41 badminton players undergo the conditions into two groups: half of the players were tested in the order of 70%-90% HRR and 90%-70% HRR with 1-5 mph stimulus speeds and the other half with the order of 70%-90% HRR and 90%-70% HRR with 5-1 mph stimulus speeds. This method of testing is known as counterbalancing and helps to reduce a bias and prevent an effect of task difficulty. Participants were not aware of which condition they had been allocated as well as their heart rate, CAT scores or other feedback during test sessions until completion of all experimental trials.

To reduce the likelihood that the participant could internally time the trial, cue delay (visual warning system) was set as random on the timer with a minimum delay of 1 and a maximum delay of 2 seconds. For each trial, the signal was initiated by the experimenter, with the participant being asked to press a trigger button, with their dominant hand, as close to the arrival time of the stimulus at the target location as possible. In other words, when the lamps are illuminated in series, participants are required to press the response switch when they anticipate the target lamp will illuminate.

Throughout whole measurement procedure, heart rate was monitoring using heart rate monitors (Polar RS400, Finland). Bassin anticipation timer was set up in close proximity to the treadmill as possible in order to minimize any delay from when the desired intensity of exercise was reached to perform CAT performances. Actually, this point here is crucial to the experimental design as the recovery process after physical exercise or fatigue which is often considered to be a limitation in experiments of this nature. In this case, if measuring the performances is not taken immediately after participant reached at the desired intensity state, simply, heart rate could decrease during this period (Duncan et al, 2013). Moreover, the total time to complete the anticipation task was less than one minute.

Coincidence anticipation timing measurements were taken in two days from 10 am to 5 pm. During both test sessions, after a brief warm-up and adequate explanation about nature of the test procedure, each participant was given 6 randomly presented trials at each of the stimulus speeds (1 & 5 mph) at bassin anticipation timer in order to familiarize themselves with the test protocol.

Based on prior researches (Lyons et al., 2008; Duncan et al., 2013; Duncan et al., 2014; Duncan et al., 2015), Resting Heart Rate (HR_{rest}) obtained from each participant by getting them to lie down in a supine position for 10-15 minutes while wearing a heart rate monitor, in a quiet room void of visual or auditory distractions. For sure, a discussion concerning exercise intensity cannot be completed without understanding the prediction of Maximal Heart Rate (HR_{max}) when a graded exercise test to maximal capacity has not been completed on the subjects.

Historically, the formula "220 - age" has been used to predict maximal heart rate in both males and females. It is simple to use but comes with a high degree of variability (underestimating HR_{max} for both gender younger than 40 years and overestimating HR_{max} for both sex older than 40 years). Recently, one of the most accurate predictor of maximal heart rate (most accurate HR_{max}) has been introduced by Thompson, Gordon, and Pescatello (2009, p. 155). Accordingly, maximum heart rate was estimated as 206.9 minus the participant's age multiply by 0.67. Both HR_{rest} and HR_{max} then was used to record and calculate 70% and 90% HRR (Appendix E) in line with prior studies (Lyons et al., 2008; Duncan et al., 2013). As an example, 90% HRR is calculated as:

$$HR_{max} = 206.9 - (0.67 \times age)$$

$$Target\ Heart\ Rate\ (THR)_{90\%}$$

$$= 90\%\ of\ Heart\ Rate\ Reserve$$

$$(THR)_{90\%} = HR_{rest} + 0.90\ (HR_{max} - HR_{rest})$$

Moderate- and high-intensity exercise conditions were induced on a motorized treadmill using an incremental running protocol. The protocol starts at a running speed of 5 mph and then the workload increases by 1 mph every 30 seconds until the participants reach the desired intensity as determined by 70% and 90% HRR. In the current study, the thresholds of 70% HRR and 90% HRR were used as indicative of moderate- and high-intensity exercise states based on prior studies (Lyons et al., 2006a; Lyons et al., 2008; Duncan et al., 2013). Once the desired intensity was reached, participants then required to maintain this intensity for a further minute. This ensure that participants were truly at the desired steady-state intensity as Lyons et al. (2008) and Duncan et al. (2013) highlighted beforehand. However, there was an exception that participants in the study of Duncan and colleagues still continued running at the set intensity on the treadmill to complete the coincidence anticipation timing trials.

Once the desired intensity (70% or 90% HRR) was reached on a treadmill, at this point the participant was immediately allowed to sit on a chair and perform 20 trials of the coincidence anticipation task at each of the stimulus speeds (1 & 5 mph). A chair was placed 2 meters away from the centre of the device directly in front of the target light (the last light in the runway). The stimulus speeds were adjusted as 1 and 5 mph indicated as low and high, respectively, for the present study. Considering the length of the bassin anticipation timer runway and stimulus speeds, participants had 2.2 sec. (for low stimulus speed) and 0.44 sec. (for high stimulus speed) for each trial between illuminating of the first red light and the target light (Akpinar et al., 2012). There was minimum of 2 hours resting period between measurement parts (rest condition, moderate, & high exercise intensity conditions). For each trial, scores were recorded in milliseconds in a record sheet (Appendix D) whether the response was early or late. The starting and ending speeds remained constant at 1 and 5 mph stimulus speeds for all trials.

3.4 Statistical Analyses

Performance could be assessed by different tasks in motor behaviour which may be categorised into three groups: 1) time; the duration of the movement from when performer responds to the stimulus (for example, reaction time, movement time, and etc.); 2) response magnitude; provide information about the movement characteristics such as the height of the high jump, and 3) accuracy of error; accuracy of the movement is the other motor behaviour measuring method which can be evaluated by three common error scores (constant error, variable error, & absolute error).

The main purpose of this section is to evaluate and interpret measurement errors (error scores) of the data collected. For this aim, raw scores were expressed as the mean and standard deviation. Each participant's raw scores were transformed into absolute constant error (|CE|) for accuracy and variable error (VE) for consistency across all experimental conditions to generate the dependent variables. This is consistent with the recognised protocols using coincidence anticipation timing tasks.

According to the research questions, a number of analyses were performed to indicate the differences between male and females' coincidence anticipation timing accuracy and consistency at different exercise intensities and stimulus speeds. The effects of exercise intensity (rest condition, moderate, & high) and gender as well as stimulus speed (1 & 5 mph) and gender and also exercise intensity and stimulus speed on accuracy and consistency of CAT scores were separately analysed conducting mixed model ANOVA. In the following, a schematic representation of the statistical design are shown in tables 3.1, 3.2, and 3.3.

Table 3.1 Statistical Design for Exercise Intensity × Gender

Error Measurements	Gender	Exercise Intensity	Mean	*SD*
Error Measurement	Male	Rest		
		Moderate		
		High		
		Total		
	Female	Rest		
		Moderate		
		High		
		Total		
	Total	Rest		
		Moderate		
		High		

The within-participant factors were exercise intensities (rest, moderate & high) and stimulus speeds (1 & 5 mph) and the between-participant factor was gender (male & female). Also, gender, exercise intensity, and stimulus speed were independent variables, whereas, coincidence anticipation timing accuracy and consistency (|CE| & VE) were dependent variables.

Table 3.2 Statistical Design for Stimulus Speed × Gender

Error Measurement	Gender	Stimulus Speed	Mean	*SD*
Error Measurement	Male	1 mph		
		5 mph		
		Total		
	Female	1 mph		
		5 mph		
		Total		
	Total	1 mph		
		5 mph		

According to the last two research questions in terms of investigating the effect of exercise intensity and stimulus speed on coincidence anticipation timing, both variables were within-participants factors. Hence, two-way repeated-measures ANOVA was used for this aim. The independent-samples t-test and paired-samples t-test were performed when necessary to show that if there was a statistically significant difference between male and females' coincidence anticipation timing accuracy and consistency through different exercise intensities.

Table 3.3 Statistical Design for Exercise Intensity × Stimulus Speed

Error Measurements	Exercise Intensity	Stimulus Speed	Mean	*SD*
Error Measurement	Rest	1 mph		
		5 mph		
		Total		
	Moderate	1 mph		
		5 mph		
		Total		
	High	1 mph		
		5 mph		
		Total		

The main assumptions underlying mixed model ANOVA are as: 1) random sample (the cases represent a random sample from the population which is difficult in real-life research); 2) independence of observations (there is no dependency in the scores between participants); 3) normal distribution (the dependent variable is normally distributed in the population for each level of the within subjects factor); 4) homogeneity of variance (variability of scores for each of the groups is similar); 5) spherecity (variance of the differences between any levels of a within-participants factors are equal across all the groups in the population).

Normality tests of dependent variables (accuracy & consistency of coincidence anticipation timing performance) at each level of each independent variables (exercise intensity, stimulus speed, & gender) were explored to examine the validity of normality assumption by using

Kolmogorov-Smirnov and Shapiro-Wilk's tests. Homogeneity of variance was evaluated using Levene's test to demonstrate the quality of variances among the between-participants factor ($p < .05$). Finally, to test the assumption of sphericity, Mauchly's test was used to show that variance of the differences between levels of within-participants factors are equal across all the groups in the population and when violated, the Huynh-Feldt and Greenhouse-Geisser adjustments were compensated this violation. A statistical significance of 0.05 was set in Statistical Package for Social Sciences (SPSS, Version 21, IBM, USA) for all statistical tests.

Finally, it seems to be useful to briefly explain the dependent measures. The dependent variables (|CE| & VE) were as follows:

- Absolute Constant Error (|CE|) or bias: Represents the bias of a group's performance when signed scores cancel each other out. Absolute constant error measures the accuracy of the coincidence anticipation timing scores. High scores show that the performance is inaccurate. Whereas, less absolute constant error means the better performances.

- Variable error (VE) or consistency: The participant's standard deviation from his or her means response; this represents the variability (consistency) of responses and a high VE means that the performance is inconsistent, while a low VE shows that the scores are very similar.

CHAPTER IV

RESULTS

The current chapter presents detailed information about the results of this thesis into three sections. In the first and second sections, the effect of exercise intensity and stimulus speed on coincidence anticipation timing will be explained with respect to gender. In the third section, the effects of exercise intensity and stimulus speed on CAT will be presented. The related assumption tests and descriptive analyses were done and briefly explained in six sub-sections. Each participant's raw scores were expressed as mean and standard deviation and dependent variables were absolute constant error (accuracy) and variable error (consistency) for all testes.

4.1 Exercise Intensity & Gender

4.1.1 Exercise Intensity × Gender at 1 mph Stimulus Speed

Absolute Constant Error (|CE|): A 2 × 3 (gender × exercise intensity) mixed model ANOVA was used to test if coincidence anticipation timing accuracy differed between genders (male & female) within three exercise intensities (rest, moderate, & high) at 1 mph stimulus speed. All the assumptions (normality, homogeneity, & sphericity) for absolute constant error were checked. Although the normality and homogeneity of variance tests did not show a violation, the assumption of sphericity was not satisfied for exercise intensity by using Mauchly's test, $W(2) = 0.73$, $p < .05$. Hence, Huynh-Feldt correction was applied to compensate this violation. The descriptive statistics is shown in Table 4.1. The result of analysis for |CE| indicated that there was no significant interaction between gender and exercise intensity, $F(2,78) = 1.73$, $p > .05$. Also, there was no main effect for exercise intensity, $F(2,78) = 2.21$, $p > .05$, suggesting that ignoring the gender of the participants, there was no significant difference in coincidence anticipation timing accuracy across three conditions (this is known as exercise intensity main effect). However, there was a significant main effect for gender, $F(1,39) = 11.82$, $p < .05$, showing that ignoring the effect of exercise intensity, there was a significant difference between male and female players' CAT accuracy (this is known as gender main effect). The pairwise comparisons for the gender main effect indicated that in overall, males ($M = 47.35$, $SD = 15.50$) had significantly less |CE| than females ($M = 64.32$, $SD = 19.88$) as it is seen at Figure 4.1.

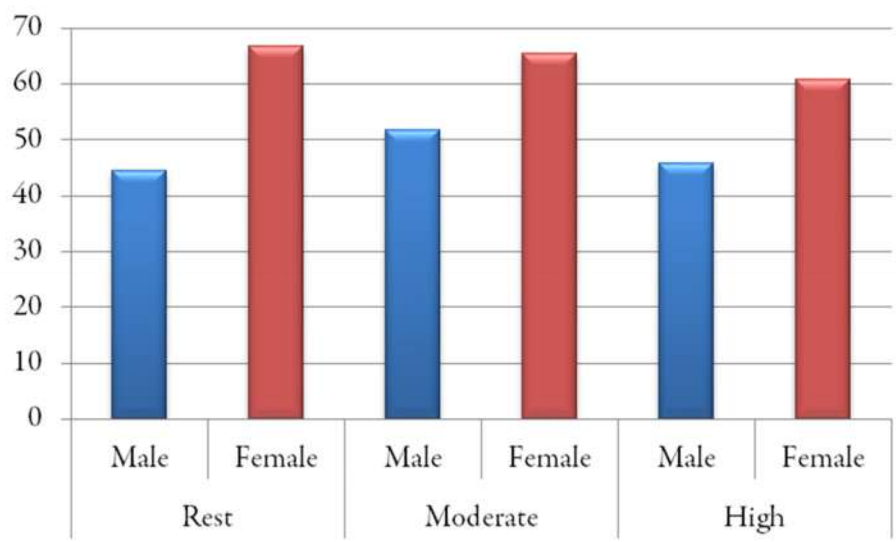

Figure 4.1 Exercise Intensity × Gender at 1 mph Stimulus Speed on |CE|

In addition, a number of paired-samples t-tests showed that there was a significant difference in accuracy of males' performances within rest ($M = 44.46$, $SD = 15.32$) condition and moderate ($M = 51.75$, $SD = 20.57$) exercise intensity, $t(19) = 1.93$, $p = .07$. However, female players' accuracy significantly differed across rest (*M* = 66.73, *SD* = 18.46) condition and high (*M* = 60.85, *SD* = 16.23) exercise intensity, $t(20) = 1.93$, $p = .07$.

Table 4.1 Exercise Intensity × Gender on |CE| and VE at 1 mph Stimulus Speed

Error Measurements	Gender	Exercise Intensity	Mean	*SD*
|CE|	Male	Rest	44.46	15.32
		Moderate	51.75	20.57
		High	45.83	10.61
		Total	47.35	15.50
	Female	Rest	66.73	18.46
		Moderate	65.39	24.95
		High	60.85	16.23
		Total	64.32	19.88
	Total	Rest	55.86	20.22
		Moderate	58.73	23.66
		High	53.53	15.59
VE	Male	Rest	43.88	14.37
		Moderate	49.39	19.88
		High	46.79	13.86
		Total	46.69	16.04
	Female	Rest	60.53	13.55
		Moderate	53.38	13.15
		High	53.54	14.16
		Total	55.82	13.62
	Total	Rest	52.41	16.15
		Moderate	51.43	16.68
		High	50.25	14.25

Note. *N* = 41 (Male: n = 20, Female: n = 21). There was a total number of 20 CAT trials (measured in milliseconds) for each exercise intensity per person.

Variable Error (VE): A 2 × 3 (gender × exercise intensity) mixed model ANOVA was performed to test if coincidence anticipation timing consistency (VE) differed between genders within three exercise intensities at 1 mph stimulus speed. Similar to |CE|, whole assumptions (normality, homogeneity, & sphericity) of variable error were checked.

Although the normality and homogeneity of variance tests were satisfied, the assumption of sphericity for exercise intensity was not met showing by Mauchly's test, $W(2) = 0.76$, $p < .05$. Therefore, the Huynh-Feldt correction was applied to compensate this violation. The descriptive statistics is indicated in Table 4.1. The result of analysis for VE showed that there was a significant interaction between gender and exercise intensity, $F(2,78) = 3.73$, $p < .05$ (this is known as gender × exercise intensity interaction). It means that the consistency of CAT scores significantly vary between genders within three exercise intensities. An independent-samples t-test showed that there was a significant difference between genders at rest condition, $t(39) = 3.82$, $p = .00$, indicating that males ($M = 43.88$, $SD = 14.37$) had significantly better consistency than females ($M = 60.53$, $SD = 13.55$). In addition, the lower amount of variability for males was observed at moderate and high exercise intensities over females, but not significant. Looking more closely at Figure 4.2, it is plain to see that male players had higher consistency (lower VE) in all conditions than females.

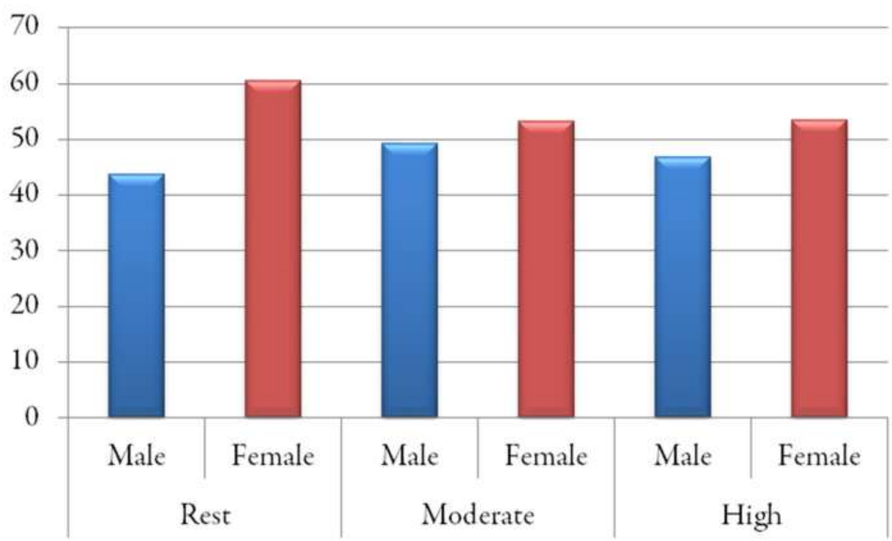

Figure 4.2 Exercise Intensity × Gender at 1 mph Stimulus Speed on VE

The results of paired-samples t-tests demonstrated that there were no significant differences between males' scores consistency within rest ($M = 43.88$, $SD = 14.37$) condition, moderate

($M = 49.39$, $SD = 19.88$), and high ($M = 46.79$, $SD = 13.86$) exercise intensities ($p > .05$). However, females were significantly inconsistent at rest condition ($M = 60.53$, $SD = 13.55$) compared to moderate ($M = 53.38$, $SD = 13.15$), $t(20) = 2.91$, p = .01, and high ($M = 53.54$, $SD = 14.16$), $t(20) = 2.19$, p = .04, exercise intensities.

4.1.2 Exercise Intensity × Gender at 5 mph Stimulus Speed

Absolute Constant Error (|CE|): A 2 × 3 mixed model ANOVA was conducted to test whether coincidence anticipation timing accuracy differed between genders at three exercise intensities at 5 mph stimulus speed. All the assumptions were checked, however, there was just violation for the assumption of sphericity for exercise intensity identified by Mauchly's test, $W(2) = 0.77$, $p < .05$. As a consequence, the Huynh-Feldt correction was used for compensation. The mean and standard deviation of the scores is shown in Table 4.2. The result of analysis for |CE| depicted that there were neither significant interaction between gender and exercise intensity, $F(2,78) = .72$, $p > .05$, nor main effect for gender, $F(1,39) = .70$, $p > .05$, and exercise intensity as well, $F(2,78) = .66$, $p > .05$ (see Figure 4.3).

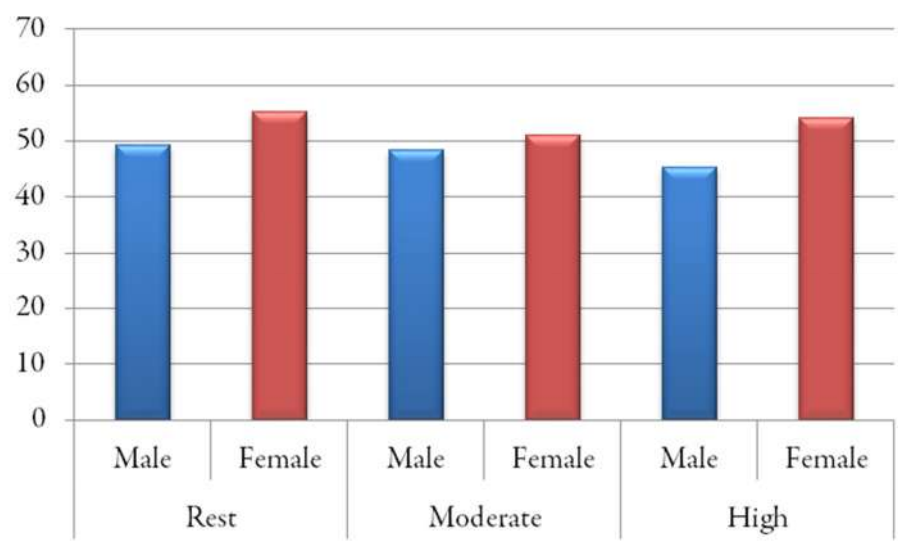

Figure 4.3 Exercise Intensity × Gender at 5 mph Stimulus Speed on |CE|

Table 4.2. Exercise Intensity × Gender on |CE| and VE at 5 mph Stimulus Speed

Error Measurements	Gender	Exercise Intensity	Mean	*SD*
|CE|	Male	Rest	49.30	27.02
		Moderate	48.37	31.97
		High	45.47	24.69
		Total	47.71	27.89
	Female	Rest	55.35	20.57
		Moderate	51.21	18.16
		High	54.28	21.77
		Total	53.61	20.17
	Total	Rest	52.40	23.83
		Moderate	49.83	25.54
		High	49.98	23.37
VE	Male	Rest	45.90	18.05
		Moderate	41.52	24.33
		High	40.35	13.52
		Total	42.59	18.63
	Female	Rest	49.12	13.99
		Moderate	42.74	10.89
		High	49.89	17.44
		Total	47.25	14.11
	Total	Rest	47.55	15.98
		Moderate	42.14	18.47
		High	45.24	16.19

Note. $N = 41$ (Male: n = 20, Female: n = 21). There was a total number of 20 CAT trials (measured in milliseconds) for each exercise intensity per person.

Additionally, a number of paired-samples t-tests revealed that there were no significant differences in performance accuracy of male players within rest ($M = 49.30$, $SD = 27.02$) condition, moderate ($M = 48.37$, $SD = 31.97$), and high ($M = 45.47$, $SD = 24.69$) exercise intensities ($p > .05$). Likewise, females' accuracy did not differ significantly across rest ($M = 55.35$, $SD = 20.57$) condition, moderate ($M = 51.21$, $SD = 18.16$), and high ($M = 54.28$, $SD = 21.77$) exercise intensities ($p > .05$). Plus, the findings demonstrated that in overall, female players had statistically more accurate CAT performances at higher ($M = 53.61$, *SD*

= 20.17) stimulus speed (5 mph) compared to low (*M* = 64.32, *SD* = 19.88) stimulus speed (1 mph), *t*(62) = 3.97, *p* = 00. In males however, there were no significant differences between performance accuracy at 5 mph (*M* = 47.71, *SD* = 27.89) and 1 mph (*M* = 47.35, *SD* = 15.50) stimulus speeds, *t*(59) = .13, *p* = .90.

Variable Error (VE): A 2 × 3 (gender × exercise intensity) mixed model ANOVA was conducted to test whether coincidence anticipation timing consistency differed between male and female players at exercise intensities at 5 mph stimulus speed. In terms of the assumption check, the assumption of sphericity for exercise intensity was not satisfied using Mauchly's test, $W(2) = 0.83, p < .05$. For compensating of this violation, the Huynh-Feldt correction was used. However, all the other assumptions (normality, homogeneity) were satisfied. All means and standard deviations of CAT scores are illustrated in the Table 4.2. The result of analysis for VE as similar to |CE| showed that there were neither significant gender × exercise intensity interaction, $F(2,78) = 1.09, p > .05$, nor main effects for exercise intensity, $F(2,78) = 1.69, p > .05$, and gender $F(1,39) = 1.34, p > .05$.

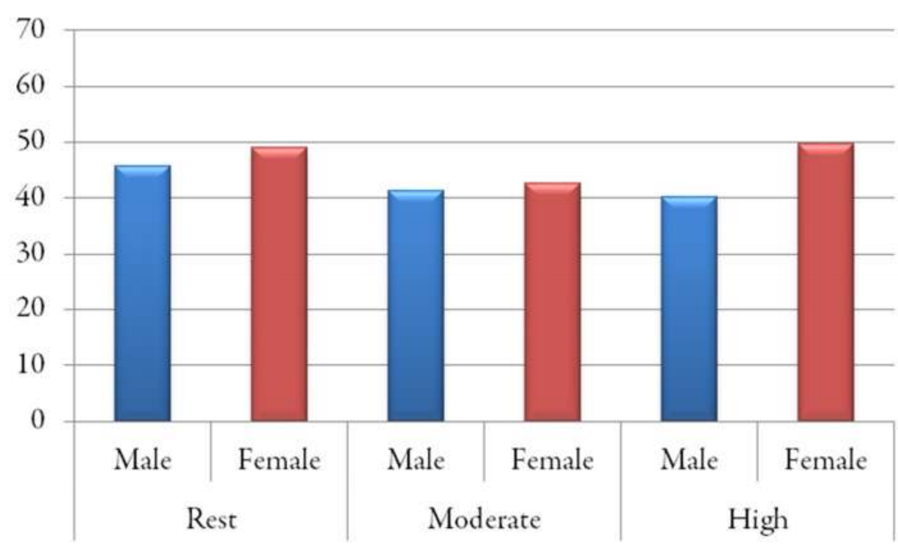

Figure 4.4 Exercise Intensity × Gender at 5 mph Stimulus Speed on VE

The outcomes of paired-samples t-tests depicted that there were no significant differences in performance consistency of males within rest (*M* = 45.90, *SD* = 18.05) condition, moderate (*M* = 41.52, *SD* = 24.33), and high (*M* = 40.35, *SD* = 13.52) exercise intensities ($p > .05$). However, females were more consistent at moderate (*M* = 42.74, *SD* = 10.89) exercise intensity compared to rest (*M* = 49.12, *SD* = 13.99) condition, $t(20) = 2.12$, $p = .05$, and high (*M* = 49.89, *SD* = 17.44) intensity exercise, $t(20) = 2.60$, $p = .02$. In overall, males were significantly consistent at higher (*M* = 42.59, *SD* = 18.63) stimulus speed (5 mph) when comparing to lower (*M* = 46.69, *SD* = 16.04) speed (1 mph), $t(59) = 2.26$, $p = .03$. Similarly, females (*M* = 47.25, *SD* = 14.11) had much more consistent performances when anticipating at faster stimulus speed (5 mph) compared to slower (*M* = 55.82, *SD* = 13.62) speed (1 mph), $t(62) = 4.22$, $p = 00$.

4.2 Stimulus Speed & Gender

4.2.1 Stimulus Speed × Gender at Rest Condition

Absolute Constant Error (|CE|): A 2 × 2 (gender × stimulus speed) mixed model ANOVA was performed to test if coincidence anticipation timing accuracy differed between males and females at two stimulus speeds (1 & 5 mph) at rest condition. The assumptions of normality and homogeneity were checked, except the assumption of sphericity for stimulus speed, because it has only two levels at current study, therefore there was no need to worry about sphericity. Descriptive statistics are shown in Table 4.3. The analysis of |CE| indicated that there was a significant interaction between gender and stimulus speed, $F(1,39) = 6.15$, $p < .05$. It means that the accuracy of coincidence anticipation timing scores changed significantly between male and female players across 1 and 5 mph stimulus speeds at rest condition. An Independent-samples t-test was used to compare the accuracy of the CAT score means within stimulus speeds. The results showed that there was a statistically significant difference between genders at 1 mph stimulus speed, *t*(39) = 4.19, *p* = .00, with males (*M* = 44.46, *SD* = 15.32) executed better performance with high accuracy than females (*M* = 66.73, *SD* = 18.46) as it could be seen at figure 4.5.

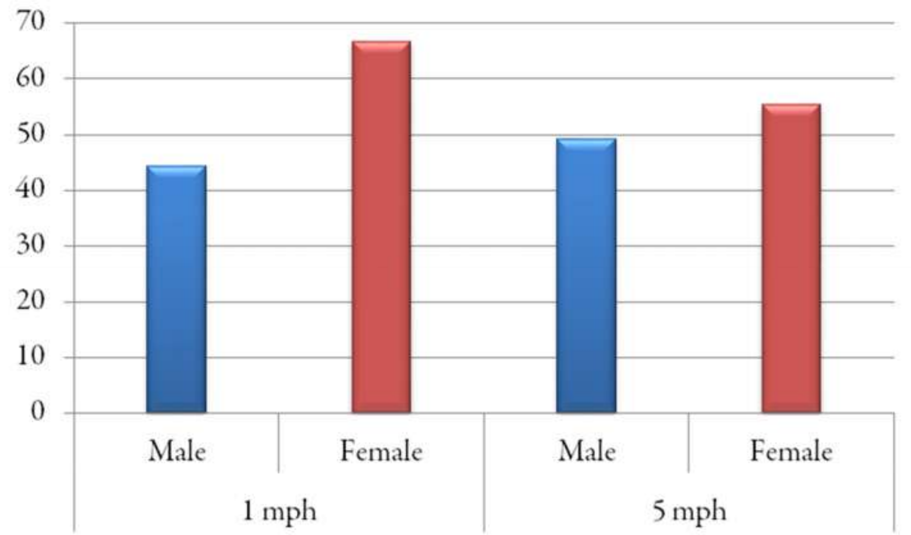

Figure 4.5 Stimulus Speed × Gender at Rest Condition on |CE|

A number of paired-samples t-tests were done and finally the results revealed that there were no significant differences between performance accuracy of males within 1mph (*M* = 44.46, *SD* = 15.32) and 5 mph (*M* = 49.30, *SD* = 27.02) stimulus speeds at rest condition, *t*(19) = 1.02, *p* = .32. Nevertheless, the results depicted that females were significantly accurate at higher (*M* = 55.35, *SD* = 20.57) stimulus speed (5 mph) in comparison to low (*M* = 66.73, *SD* = 18.46) speed (1 mph), *t*(20) = 2.53, *p* = .02.

Table 4.3. Stimulus Speed × Gender on |CE| and VE at Rest Condition

Error Measurements	Gender	Stimulus Speed	Mean	*SD*
|CE|	Male	1 mph	44.46	15.32
		5 mph	49.30	27.02
		Total	46.88	21.17
	Female	1 mph	66.73	18.46
		5 mph	55.35	20.57
		Total	61.04	19.52
	Total	1 mph	55.86	20.22
		5 mph	52.40	23.83
VE	Male	1 mph	43.88	14.37
		5 mph	45.90	18.05
		Total	44.89	16.21
	Female	1 mph	60.53	13.55
		5 mph	49.12	13.99
		Total	54.83	13.77
	Total	1 mph	52.41	16.15
		5 mph	47.55	15.98

Note. $N = 41$ (Male: n = 20, Female: n = 21). There was a total number of 20 CAT trials (measured in milliseconds) for each stimulus speed per person.

Variable Error (VE): A 2 × 2 (gender × stimulus speed) mixed model ANOVA was conducted to test whether the variability of coincidence anticipation timing differed between genders across two stimulus speeds at rest condition. As similar to |CE|, all the assumptions were checked except the assumption of sphericity for stimulus speed due to its just two levels. The descriptive statistics is indicated in Table 4.3. The analysis showed that there was a significant interaction between gender and stimulus speed, $F(1,39) = 9.16$, $p < .05$. It means that the consistency of CAT scores changed significantly between genders across 1 and 5 mph stimulus speeds at rest condition. An independent-samples t-test was used to compare the CAT scores' consistency. The results were similar to |CE| which indicated a statistically significant difference between genders at 1 mph stimulus speed, $t(39)$

= 3.82, *p* = .00. As it is seen at Figure 4.6, males (*M* = 43.88, *SD* = 14.37) had much more similar CAT scores than females (*M* = 60.53, *SD* = 13.55) at 1 mph stimulus speed.

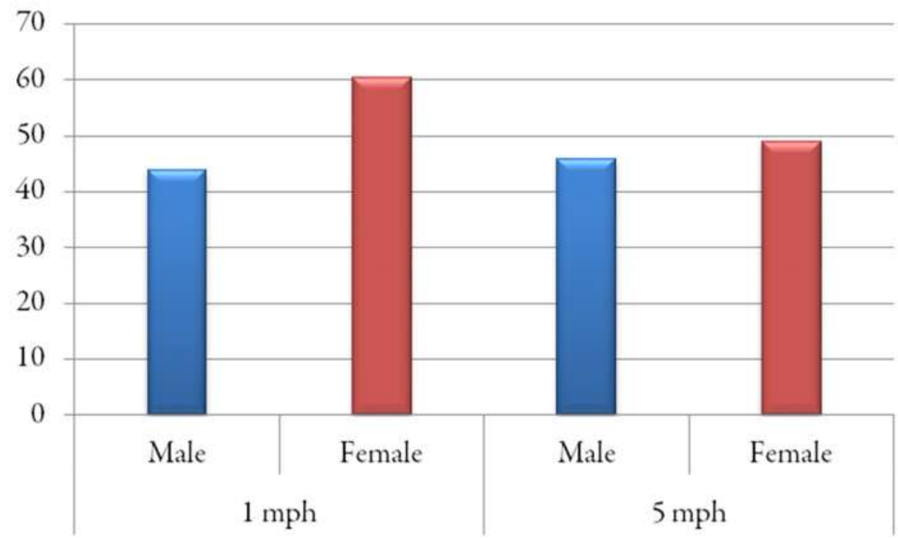

Figure 4.6 Stimulus Speed × Gender at Rest Condition on VE

As similar to |CE|, a number of paired-samples t-tests indicated that there were no significant differences between performance consistency of males within 1mph (*M* = 43.88, *SD* = 14.37) and 5 mph (*M* = 45.90, *SD* = 18.05) stimulus speeds at rest condition *t*(19) = .75, *p* = .47. Nevertheless, the results depicted that females were significantly consistent at higher (5 mph) stimulus speed (*M* = 49.12, *SD* = 13.99) in comparison to low (1 mph) speed (*M* = 60.53, *SD* = 13.55), *t*(20) = 3.28, *p* = 00.

4.2.2 Stimulus Speed × Gender at Moderate Exercise Intensity

Absolute Constant Error (|CE|): A 2 × 2 (gender × stimulus speed) mixed model ANOVA was performed to show whether coincidence anticipation timing accuracy differed between genders at 1 and 5 mph stimulus speeds at moderate exercise intensity. All the assumptions (normality, homogeneity) were checked. However, there was no need for testing sphericity for stimulus speed because of lower than three levels. The descriptive statistics is indicated in Table 4.4. The result of |CE| showed that there was no significant interaction between gender and stimulus speed, $F(1,39) = 1.99$, $p > .05$. In terms of main effects, there was no main effect for gender, $F(1,39) = 1.56$, $p > .05$, but there was a main effect for stimulus speed, $F(1,39) = 5.27$, $p < .05$. Stimulus speed main effect means that ignoring the gender of the participants, there was a significant difference in coincidence anticipation timing accuracy across two stimulus speeds. The pairwise comparisons for the stimulus speed main effect showed that participants had highly accurate CAT scores at 5 mph ($M = 49.83$, $SD = 25.54$) than 1 mph ($M = 58.73$, $SD = 23.66$) stimulus speed (see Figure 4.7).

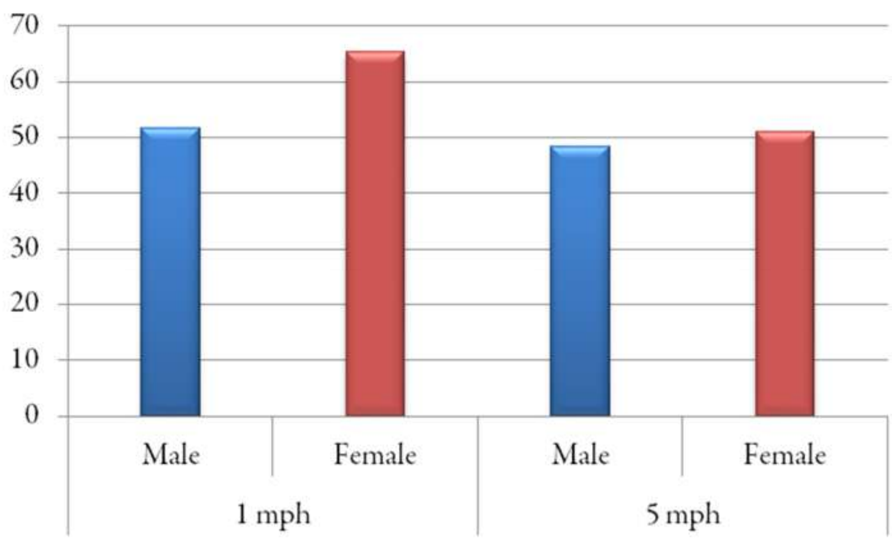

Figure 4.7 Stimulus Speed × Gender at Moderate Exercise Intensity on |CE|

A number of paired-samples t-tests revealed no significant difference in terms of accuracy of performance in males within 1 mph ($M = 51.75$, $SD = 20.57$) and 5 mph ($M = 48.37$, $SD = 31.97$) stimulus speeds, $t(19) = .61$, $p = .55$. However, females had more accurate scores at 5 mph ($M = 51.21$, $SD = 18.16$) stimulus speed in comparison to 1 mph ($M = 65.39$, $SD = 24.95$) speed, $t(20) = 2.67$, $p = .02$. Moreover, the results also showed that in overall, there were no significant differences in performance accuracy of males between rest (M = 46.88, SD = 21.17) condition and moderate (M = 50.06, SD = 26.27) exercise intensity, $t(39)$ = 1.01, p = .32, as well as females' accuracy between rest (M = 61.04, SD = 19.52) and moderate (M = 58.30, SD = 21.56) intensity, $t(41)$ = .99, p = .33.

Table 4.4 Stimulus Speed × Gender on |CE| and VE at Moderate Exercise Intensity

Error Measurement	Gender	Stimulus Speed	Mean	*SD*
|CE|	Male	1 mph	51.75	20.57
		5 mph	48.37	31.97
		Total	50.06	26.27
	Female	1 mph	65.39	24.95
		5 mph	51.21	18.16
		Total	58.30	21.56
	Total	1 mph	58.73	23.66
		5 mph	49.83	25.54
VE	Male	1 mph	49.39	19.88
		5 mph	41.52	24.33
		Total	45.46	22.11
	Female	1 mph	53.38	13.15
		5 mph	42.74	10.89
		Total	48.06	12.02
	Total	1 mph	51.43	16.68
		5 mph	42.14	18.47

Note. N = 41 (Male: n = 20, Female: n = 21). There was a total number of 20 CAT trials (measured in milliseconds) for each stimulus speed per person.

Variable Error (VE): A 2 × 2 (gender × stimulus speed) mixed model ANOVA was used to test if the consistency of coincidence anticipation timing recorded from participants differed between genders at two stimulus speeds at moderate exercise intensity. All the assumptions (normality, homogeneity) were checked. Nevertheless, there was no need for testing the assumption of sphericity for stimulus speed because of its two levels. The descriptive analysis is shown at table 4.4. The mean and standard deviation are given in Table 4.4. The result of consistency showed that there was no significant interaction between gender and stimulus speed, $F(1,39) = .35$, $p > .05$. Also there was no main effect for gender, $F(1,39) = .27$, $p > .05$, but there was a main effect for stimulus speed, $F(1,39) = 15.56$, $p < .05$. This means that ignoring whether participants were male or female, there was a significant difference in CAT variability across two stimulus speeds. The pairwise comparisons for the stimulus speed main effect depicted that there was a statistically significant CAT variability difference across stimulus speeds with more consistent performances at 5 mph ($M = 42.14$, $SD = 18.47$) than 1 mph ($M = 51.43$, $SD = 16.68$) stimulus speed (see Figure 4.8).

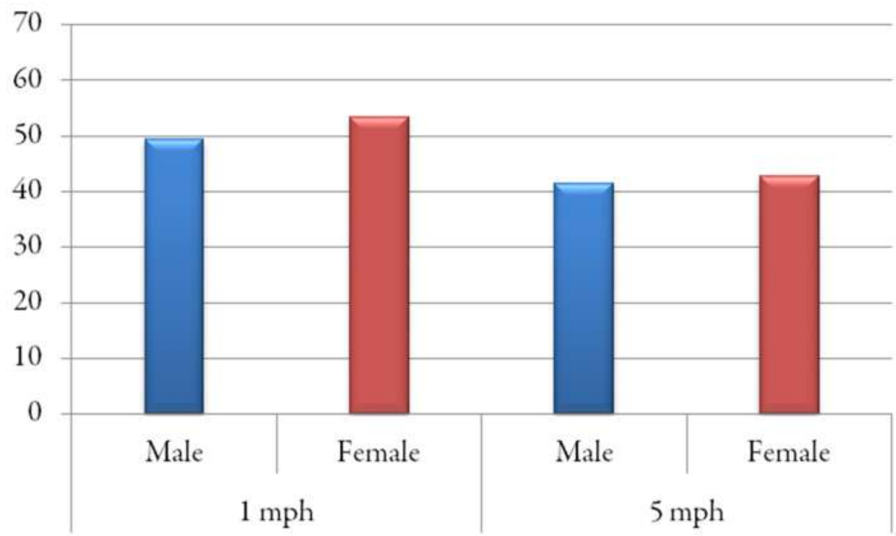

Figure 4.8 Stimulus Speed × Gender at Moderate Exercise Intensity on VE

A number of paired-samples t-test revealed that there was a significant difference between performance consistency of males within 1 mph ($M = 49.39$, $SD = 19.88$) stimulus speed and 5 mph ($M = 41.52$, $SD = 24.33$) speed, $t(39) = .16$, $p = .87$. Females also, had more similar performances at 5 mph ($M = 53.38$, $SD = 13.15$) stimulus speed compared to 1 mph ($M = 42.74$, $SD = 10.89$) speed, $t(41) = 3.52$, $p = 00$. The results also indicated that the consistency of males' performances did not differ significantly between rest ($M = 44.89$, $SD = 16.21$) condition and moderate ($M = 45.46$, $SD = 22.11$) exercise intensity, $t(39) = .16$, p

= .87. However, females had mconsistent scores at moderate (*M* = 48.06, *SD* = 12.02) exercise intensity compared to rest (*M* = 54.83, *SD* = 13.77) condition, *t*(41) = 3.52, *p* = 00.

4.2.3 Stimulus Speed × Gender at High Exercise Intensity

Absolute Constant Error (|CE|): A 2 × 2 (gender × stimulus speed) mixed model ANOVA was performed to investigate if coincidence anticipation timing accuracy differed between male and female players through two stimulus speeds at high exercise intensity. The assumptions of normality and homogeneity were checked, except the assumption of sphericity for stimulus speed because of only two levels; therefore, there was no need to worry about sphericity. The table 4.5 shows the descriptive statistics.

The result of |CE| depicted that there was no significant interaction between gender and stimulus speed, $F(1,39) = .94$, $p > .05$. In terms of main effects, there was no main effect for stimulus speed, $F(1,39) = 1.17$, $p > .05$, but there was a main effect for gender, $F(1,39) = 5.59$, $p < .05$. Gender main effect means that ignoring whether participants were tested at 1 or 5 mph stimulus speeds, significant difference between genders was observed. The pairwise comparisons for the gender main effect indicated that there was a statistically significant CAT consistency difference between genders with more consistent performances of male (*M* = 45.65, *SD* = 17.65) than female (*M* = 57.57, *SD* = 19.00) players as it is showed at Figure 4.9.

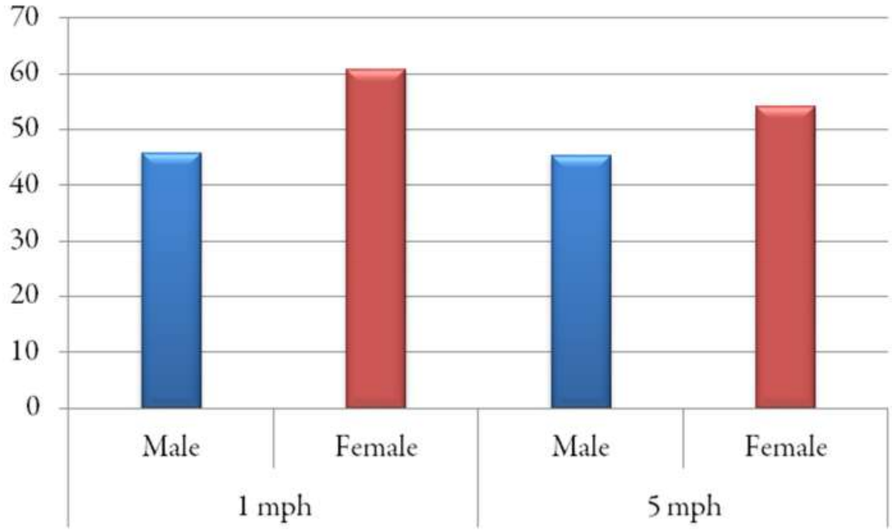

Figure 4.9 Stimulus Speed × Gender at high Exercise Intensity on |CE|

A number of paired-samples t-tests depicted that there was no significant difference between performance accuracy of males within 1 mph (*M* = 45.83, *SD* = 10.61) stimulus speed and 5 mph (*M* = 45.47, *SD* = 24.69) speed, $t(19) = .08$, $p = .94$. Likewise, there was females' accuracy did not differ significantly across 1 mph (*M* = 60.85, *SD* = 16.23) stimulus speed and 5 mph (*M* = 54.28, *SD* = 21.77) speed, $t(20) = 1.55$, $p = .14$. The results also indicated that in overall, there was no significant difference between performance accuracy of males between high (*M* = 45.65, *SD* = 17.65) exercise intensity and rest (*M* = 46.88, *SD* = 21.17) condition, $t(39) = .81$, $p = .42$, as well as high and moderate (*M* = 50.06, *SD* = 26.27) exercise intensities, $t(39) = 1.53$, $p = .13$. Similarly, the accuracy of CAT performances in females did not change significantly between high (*M* = 57.57, *SD* = 19.00) exercise intensity and rest (*M* = 61.04, *SD* = 19.52) condition, $t(41) = 1.64$, $p = .11$, as well as high and moderate (*M* = 58.30, *SD* = 21.53) exercise intensity, $t(41) = .32$, $p = .75$.

Table 4.5 Stimulus Speed × Gender on |CE| and VE at High Exercise Intensity

Error Measurements	Gender	Stimulus Speed	Mean	*SD*
|CE|	Male	1 mph	45.83	10.61
		5 mph	45.47	24.69
		Total	45.65	17.65
	Female	1 mph	60.85	16.23
		5 mph	54.28	21.77
		Total	57.57	19.00
	Total	1 mph	53.53	15.59
		5 mph	49.98	23.37
VE	Male	1 mph	46.79	13.86
		5 mph	40.35	13.52
		Total	43.57	13.69
	Female	1 mph	53.54	14.16
		5 mph	49.89	17.44
		Total	51.72	15.80
	Total	1 mph	50.25	14.25
		5 mph	45.24	16.19

Note. $N = 41$ (Male: n = 20, Female: n = 21). There was a total number of 20 CAT trials (measured in milliseconds) for each stimulus speed per person.

Variable Error (VE): A 2 × 2 (gender × stimulus speed) mixed model ANOVA was conducted to indicate that whether the variability of CAT scores differed between genders within two stimulus speeds at high exercise intensity. The assumptions of normality and homogeneity were checked, except the assumption of sphericity for stimulus speed due to only two levels for it. Descriptive analysis is shown at the Table 4.5. The result of consistency depicted that there was no significant interaction between gender and stimulus speed, $F(1,39) = .34$, p > .05, whereas, there were both main effect for gender, $F(1,39) = 4.19$, $p < .05$, and main effect for stimulus speed, $F(1,39) = 4.44$, $p < .05$. Gender main effect means that ignoring whether participants were tested at 1 or 5 mph stimulus speeds, significant CAT variability difference between genders was observed. Pairwise comparisons for gender main effect revealed that there was a statistically significant CAT variability difference between genders with less variable scores of males (*M* = 43.57, *SD* = 13.69) than females (*M* = 51.72, *SD* = 15.80) as it is seen at Figure 4.10. Also, there was a stimulus speed main effect which means that ignoring whether participants were male or female, there was a significant difference in CAT consistency across two stimulus speeds. Pairwise comparisons for stimulus speed main effect demonstrated more consistent performances at 5 mph (*M* = 45.24, *SD* = 16.19) than 1 mph (*M* = 50.25, *SD* = 14.25).

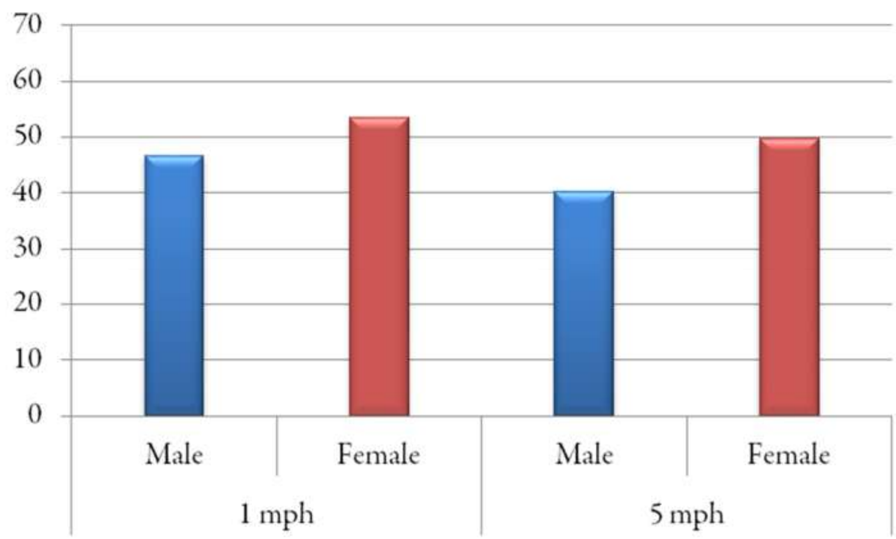

Figure 4.10 Stimulus Speed × Gender at high Exercise Intensity on VE

A number of paired-samples t-tests indicated that there was a significant difference in performance consistency of males within 1 mph (*M* = 46.79, *SD* = 13.86) stimulus speed and 5 mph (*M* = 40.35, *SD* = 13.52) speed showing more similar scores at faster stimulus speed (5 mph), $t(19) = 2.56$, $p = .02$. However, females had similar scores at 5 mph (*M* = 49.89, *SD* = 17.44) stimulus speed and 1 mph (*M* = 53.54, *SD* = 14.16) speed, $t(20) = .91$, $p = .37$. The results also indicated that in overall, there was no significant difference in performance consistency of males between high (*M* = 43.57, *SD* = 13.69) exercise intensity and rest (*M* = 44.89, *SD* = 16.21) condition, $t(39) = .61$, $p = .54$, as well as high and moderate (*M* = 45.46, *SD* = 22.11) exercise intensities, $t(39) = .49$, $p = .63$. Similarly, females' consistency did not change significantly between high (*M* = 51.72, *SD* = 15.80) exercise intensity and rest (*M* = 54.83, *SD* = 13.77) condition, $t(41) = 1.36$, $p = .18$, as well as high and moderate (*M* = 48.06, *SD* = 12.02) exercise intensity, $t(41) = 1.66$, $p = .10$.

4.3 Exercise Intensity & Stimulus Speed

Absolute Constant Error (|CE|): A 2 × 3 (stimulus speed × exercise intensity) two-way repeated-measures ANOVA was performed to investigate whether there was an overall change in coincidence anticipation timing accuracy of participants' scores within exercise intensities at stimulus speeds ignoring the gender of the participants. The assumptions of normality and sphericity were all checked. However, the homogeneity of variance was ignored because there was no between-subjects factor. The assumption of sphericity for exercise intensity, $W(2) = .78$, $p < .05$, exercise intensity and stimulus speed interaction, $W(2) = .66$, $p < .05$, were not met using Mauchly's tests. Thus, the Huynh-Feldt and Greenhouse-Geisser corrections were applied to compensate this violation. In terms of stimulus speed, there was no need to test the assumption of sphericity due to its two levels. The mean CAT scores are given in Table 4.6. The analysis of |CE| indicated that there was no a significant interaction between exercise intensity and stimulus speed, $F(2,80) = 2.51$, $p > .05$. In terms of main effects, there were neither main effect for stimulus speed, $F(1,40) = 2.87$, $p > .05$, nor exercise intensity, $F(2,80) = .93$, $p > .05$ (see Figure 4.11).

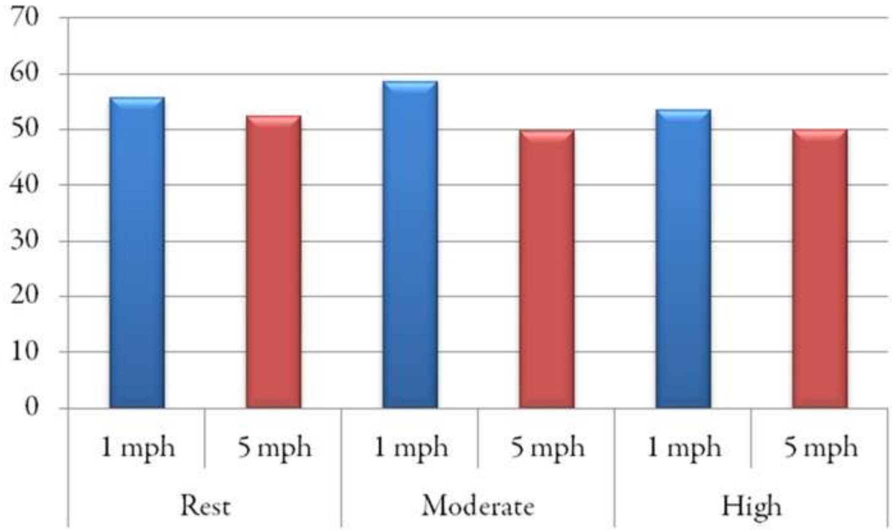

Figure 4.11 Exercise Intensity × Stimulus Speed on |CE|

A paired-samples t-tests indicated that there was a significant difference between participants' accuracy in moderate exercise intensity showing better performance at high (M = 49.83, p = 25.54) stimulus speed (5 mph) in comparison to low (M = 58.73, p = 23.66) speed (1 mph), $t(40) = 2.30$, $p = .03$. However, there was no significant difference between accuracy of performances in rest condition at 1 mph (M = 55.86, p = 20.22) and 5mph (M = 52.40, p = 23.83) stimulus speeds, $t(40) = 1.00$, $p = .32$. Also, there was no significant difference between accuracy of performances in high exercise intensity at 1 mph (M = 53.53, p = 15.59) and 5mph (M = 49.98, p = 23.37) stimulus speeds, $t(40) = 1.11$, $p = .27$.

Table 4.6 Exercise Intensity × Stimulus Speed on |CE| and VE

Error Measurements	Exercise Intensity	Stimulus Speed	Mean	*SD*
|CE|	Rest	1 mph	55.86	20.22
		5 mph	52.40	23.83
		Total	54.13	22.03
	Moderate	1 mph	58.73	23.66
		5 mph	49.83	25.54
		Total	54.28	24.60
	High	1 mph	53.53	15.59
		5 mph	49.98	23.37
		Total	51.76	19.48
	Total	1 mph	56.04	19.82
		5 mph	50.74	24.25
VE	Rest	1 mph	52.41	16.15
		5 mph	47.55	15.98
		Total	49.98	16.07
	Moderate	1 mph	51.43	16.68
		5 mph	42.14	18.47
		Total	46.79	17.58
	High	1 mph	50.25	14.25
		5 mph	45.24	16.19
		Total	47.75	15.22
	Total	1 mph	51.36	15.69
		5 mph	44.98	16.88

Note. $N = 41$ (Male: n = 20, Female: n = 21). There was a total number of 20 CAT trials (measured in milliseconds) for each exercise intensity at each stimulus speed per person.

Variable Error (VE): A 2 × 3 (stimulus speed × exercise intensity) two-way repeated-measures ANOVA was performed to investigate that if there was a significant change in coincidence anticipation timing consistency within exercise intensities at stimulus speeds ignoring of being male or female. The assumptions of normality and sphericity were all checked. Nonetheless, the homogeneity of variance was ignored because there was no between-subjects factor. The assumption of sphericity for exercise intensity was not satisfied using Mauchly's tests, $W(2) = .69$, $p < .05$. Thus, the Huynh-Feldt correction was applied to compensate this violation. The descriptive statistics are shown in Table 4.6. The analysis of VE showed that there was no interaction for exercise intensity and stimulus speed, $F(2,80) = 1.41$, $p > .05$. There was just main effect for stimulus speed, $F(1,40) = 15.38$, $p < .05$, but there was no exercise intensity main effect, $F(2,80) = 1.02$, $p > .05$. The pairwise comparisons for the stimulus speed main effect depicted significantly consistent CAT scores at 5 mph ($M = 44.98$, $SD = 16.88$; see Table 4.6) than 1 mph ($M = 51.36$, $SD = 15.69$) stimulus speed (see Figure 4.12).

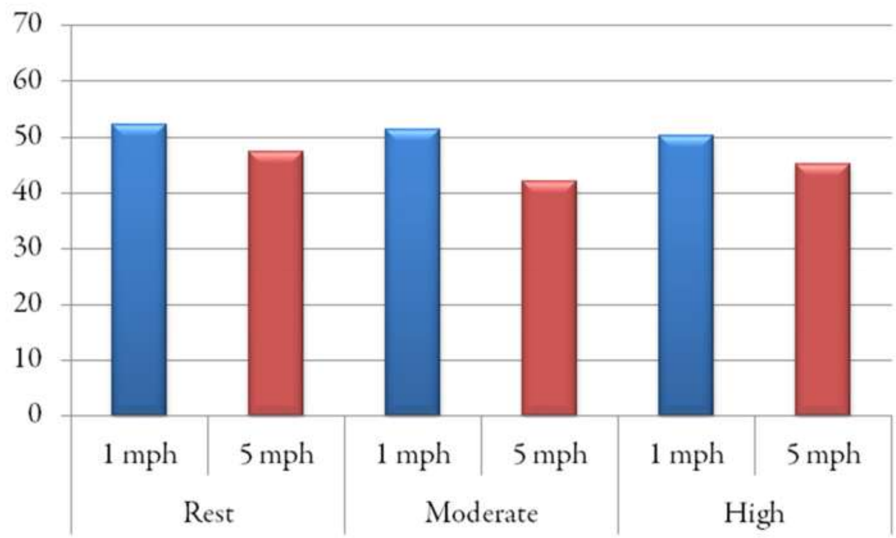

Figure 4.12 Exercise Intensity × Stimulus Speed on VE

A paired-samples t-tests showed that there was a significant difference between participants' consistency in moderate exercise intensity indicating better performance at high ($M = 42.14$, $p = 18.47$) stimulus speed (5 mph) in comparison to low ($M = 51.43$, $p = 16.68$) speed (1 mph), $t(40) = 3.99$, $p = 00$. However, there was no significant difference between consistency of performances in rest condition at 1 mph ($M = 52.41$, $p = 16.15$) and 5mph ($M = 47.55$, $p = 15.98$) stimulus speeds, $t(40) = 2.00$, $p = .05$. Plus, there was no significant difference between consistency of performances in high exercise intensity at 1 mph ($M = 50.25$, $p = 14.25$) and 5mph ($M = 45.24$, $p = 16.19$) stimulus speeds, $t(40) = 2.11$, $p = .04$.

CHAPTER V

DISCUSSION

This study was mainly designed to determine how exercise intensity and stimulus speed affect the anticipation performance between males and females. Looking more closely, the effect of gender on coincidence anticipation timing was separately examined once with exercise intensity at each stimulus speed, then with respect to stimulus speed in each exercise intensity. Furthermore, coincidence anticipation timing performance was examined ignoring whether participants were male or female with regard to exercise intensity and stimulus speed. In this section, research questions will be separately discussed with respect to the hypotheses proposed in present study as well as the findings in line with the current literature.

5.1 The Effects of Exercise Intensity & Gender on CAT

To examine the effects of exercise intensity and gender on coincidence anticipation timing at separate stimulus speeds (1 & 5 mph), four null hypotheses were formulated in the present study; a) there is no interaction between exercise intensity and gender on coincidence anticipation timing at 1 mph stimulus speed; b) exercise intensity does not have any significant effect on coincidence anticipation timing in both male and female badminton players at 1 mph stimulus speed; c) there is no interaction between exercise intensity and gender on coincidence anticipation timing at 5 mph stimulus speed; d) exercise intensity does not have any significant effect on coincidence anticipation timing in both male and female badminton players at 5 mph stimulus speed. In the following section, these hypotheses were discussed on both absolute constant error and variable error.

Absolute Constant Error (|CE|): In terms of accuracy of coincidence anticipation timing scores, the results depicted that there was a significant main effect for gender at 1 mph stimulus speed showing better performances for male players over females on CAT tasks (see Table 5.1). As a consequence, except the second null hypothesis (b), all the other hypotheses are accepted. A number of paired-samples t-tests revealed that there were significant differences in performance accuracy of males within rest condition and moderate exercise intensity at 1 mph stimulus speed. Similarly, female players' accuracy significantly differed across rest condition and high exercise intensity at 1 mph stimulus speed. Also, there were no significant differences in performance accuracy of both male and female players within all exercise intensities at 5 mph stimulus speed. The findings also demonstrated that in overall, female players had statistically more accurate CAT performances at 5 mph stimulus speed compared to 1 mph speed. In males however, there were no significant differences between performance accuracy at 5 mph and 1 mph stimulus speeds.

Table 5.1 Summary of Significant & Non-Significant Results for Exercise Intensity & Gender

Error Measurements	Sources	1 mph	5 mph
|CE|	EI × G Interaction	NS	NS
	EI Main Effect	NS	NS
	G Main Effect	M>F	NS
VE	EI × G Interaction	R: M>F	NS
	EI Main Effect	NS	NS
	G Main Effect	NS	NS

Note. EI: Exercise Intensity; G: Gender; NS: not significant; M>F: males were more accurate/consistent than females; R: rest condition.

Variable Error (VE): Speaking about the consistency of coincidence anticipation timing scores (see Table 5.1), the outcomes indicated that there was a significant interaction between exercise intensity and gender at 1 mph stimulus speed. Consequently, except the first null hypothesis (a), all the others are accepted. The results of paired-samples t-tests demonstrated that there were no significant differences between males' scores consistency within all exercise intensities at 1 mph stimulus speed. However, females were significantly inconsistent at rest condition compared to moderate and high exercise intensities at 1 mph stimulus speed. The outcomes also showed that there were no significant differences in performance consistency of males across all exercise intensities at 5 mph stimulus speed. However, females were more consistent at moderate exercise intensity in comparison with rest condition and high intensity exercise at 5 mph stimulus speed. In overall, both male and female players were significantly consistent at 5 mph stimulus speed when comparing to 1 mph speed.

In terms of gender differences on coincidence anticipation timing ability, many researchers (Williams et al., 2002; Söğüt et al., 2009; Sanders, 2011) put forward that males anticipate more accurately and consistently in comparison with their female counterparts. They believed that the more accurate coincidence anticipation timing results reported for males is due to the differences in motor factors and spatiotemporal skills (Schiff & Oldak, 1990) or also sport involvements (Petrakis, 1985). On the contrary, other researchers (Wrisberg & Mead, 1983; Ripoll & Latiri, 1997) debated that there is no significant difference between males and females' coincidence anticipation timing performance.

The results of present thesis indicated that there was a gender main effect showing that males were significantly accurate across all exercise intensities at low (1 mph) stimulus speed, but it was not significant at high speed (5 mph) though male players performed better. Additionally, males had more similar CAT scores in rest condition than their female counterparts at low (1 mph) stimulus speed.

In recent years, Lyons et al. (2013) investigated the effects of rest condition and differential exercise intensities (moderate & high) on the accuracy and consistency of groundstroke between male and female tennis players. The results suggested that both male and female tennis players performed at comparable levels under moderate (70% HR_{peak}) and high (90% HR_{peak}) exercise intensity conditions. The authors concluded that there is similarity in the responses of male and female players under moderate and high exercise intensity conditions. In overall, the study demonstrated that the impact of exercise intensity is equivocal in terms of gender differences with similar trends in performance. When the result of this thesis is compared to Lyons' et al. (2013) study, there is partly support for better performance of both males and females at high and moderate exercise intensities in comparison to rest condition, respectively. Although Lyons and colleagues (2013) reported main effect for fatigue, gender main effect was observed in the present study. On the other hand, the results of current study are partly contradictory from those of Lyons and colleagues in terms of differences between males and females which they found a similar trend in performance of both sex. Nevertheless, males were significantly accurate across all exercise intensities at low (1 mph) stimulus speed but it was not significant at high speed (5 mph) although males' performed better.

In the scientific literature, the lack of consistent results and conflicting findings with regard to the impact of exercise intensity on performance has been firstly confounded by using a wide variety of methodologies (criteria, amount of intensity, & duration) for exercise intensity, poor experimental designs, and considerable differences in the types of tasks (cognitive, sensory, & motor) utilised as well (Aks, 1998). As a consequence, for instance, performance may have not been assessed in a truly exertion state in some studies due to the recovery process from the previous exercise intensity. Consequently, real fatigue state may be induced in some studies, but may not be induced in the others.

As a second reason for conflicting results, Noakes (2000) debated that "accustomed to the tightly controlled conditions of laboratory research, some scientists may be reluctant to undertake field-based studies of performance in which all the different variables influencing human performance are not easily controlled" (Lyons, 2011, p. 57).

Thirdly, Aks (1998) and Brisswalter et al. (2002) claimed that one of the most critical limitations of some previous research studies which underpinning the wide diversity of experimental results was the failure by investigators to take individual physical fitness level differences into consideration. Eventually, McMorris and Keen (1994) were of the opinion that conflicting results may also be due in part to the fact that motor skills which need whole body movements were assessed during exercise in some investigations but after exercise in others. In summary, a number of limitations and shortcomings appeared after reviewing the study of exercise intensity/fatigue impacts on performance in the literature. Finally, it seems to be well-known that impairment of performance resulting from exercise intensity/fatigue differs according to the types and methodology of tasks used, exercise duration, and intensity of exercise.

Fatigue or intense exercise is a new topic since 20th century which has fascinated physiologists, sport psychologists and scientists, athletes and coaches due to its multifaceted nature and complex mechanism (Lyons et al., 2013; Duncan et al., 2014). In the field of sport, the inability of coping effectively with high exertion for athletes may lead to reduce the efficiency of performance, decreasing concentration, increasing the risk of injury, and finally losing the match or game (Lyons, 2011).

Despite the importance of studying fatigue and physical exertion effect, few investigations have been conducted on the effects of exercise intensity on sport performance (McMorris, 2004). To understand the exertion statement, there is a great need for describing it which a wide variety of studies synonymously used this term as exercise intensity and exercise exertion. In spite of the fact that there is still no consensus on the definition of intense exercise and exertion, Edwards (1983; as cited in Lyons, 2011, p. 5) put the best description for this term as a total breakdown in performance. By and large, almost all researchers believed that this term is pertinent to sport exertion.

A considerable amount of studies have been conducted on the impact of exercise intensity on motor, cognitive, and perceptual performance reported beneficial, detrimental, or no effects of exertion. Notwithstanding these studies, how exertion affects cognitive performance is still ambiguous. This could be resulted from the diversity of investigation methods of this topic (Brisswalter, Collardeau & René, 2002).

Recently, some investigations studying the effects of exercise intensity on sport performance have provided inconsistent results. One inconsistency in terms of experimental design is based on the wide variety of methods and criteria used to assess or for setting exercise intensity states which make a valid comparison of previous research findings difficult. For instance, a large number of researchers, utilized cycle ergometer (Al-Nakeeb & Lyons, 2007) and rowing ergometer (Al-Nakeeb et al., 2005), treadmill (Duncan et al., 2015), isokinetic dynamometers and the like to induce moderate and intense exercise conditions. To control and measure induced exertion, the diverse methods such as maximum power output (MPO), calculating heart rate reserve (HRR), rating of perceived exertion (RPE) or combination of them (HRR & RPE), and etc. were used (Lyons, 2011).

One of the earliest theories of arousal is the inverted-U theory proposed by Yerkes and Dodson (1908) in which poor performance will occur while arousal is at low level. When arousal rises to a moderate exercise intensity, performance will reach at the top of the inverted-U which results in an optimal level of performance. If arousal still continues to rise, performance will begin to deteriorate until it eventually returns to a low level of arousal. This is because when arousal is low, the attention system focuses on both task relevant and irrelevant cues so that performance would be poor. While arousal is at the top of the inverted-U, attention is limited just on the task-relevant cues so the performance is optimal. However, sport scientists who explore the effect of exercise intensity on cognitive and perceptual performance do not support this hypothesis. They supposed that the arousal theory cannot by itself account for the results of some studies which reported improved performance with moderate exercise intensity and the relationship between exercise intensity and arousal needs to be investigated in more future studies.

Yerkes and Dodson (1908) also debated that although complex tasks need to be performed well at moderate levels of arousal, high levels of arousal would result in poorer performance. Nonetheless, optimal performance of simple task needs high level of arousal. Accordingly, motor tasks requiring concentration (e.g., fine motor skills) need low or moderate levels of arousal and those requiring strength and speed (e.g., gross motor skills) are best performed in the higher levels of arousal.

Speaking about the effect of exercise intensity on cognitive performance, researchers were of the opinion that some forms of physical exercise could improve the efficiency of cognitive performance. To support this, Aks (1998) examined the visual search performance of 18 individuals after 10 minutes of low (65% workload) and high (8 minutes at 65% workload then 2 minutes at 85% workload) exercise intensity cycling on accuracy and response time. The result showed that all participants were more accurate and faster on visual search task after exercise. Additionally, other researches also claimed the improvement for cognitive performance (Brisswalter et al., 2002) and decision making (McMorris & Graydon, 1996; Tenenbaum, Yuval, Elbaz, Bar-Eli, & Weinberg, 1993) after exercise. On the other hand, Tomporowski (2003) was of the opinion that human body has the capability of coping with high exercise intensity to maintain cognitive performance. As a consequence, Tomporowski debated that exercise intensity has no effect on cognitive performance.

The importance of reaction time in sport such as ice hockey, hurling and fencing is undeniable to successful performance. The interactions between cognitive and physiological processes have been extensively studied using simple and choice reaction time procedures within laboratory settings (Lyons, 2011). In the one hand, some studies claimed that there is no impact of physical intensity on reaction time (Lulofs, Wennekens, & Van Houtem, 1981). On the other hand, other researches demonstrated that exertion had a detrimental impact on reaction time (Legros, Delignières, Durand, & Brisswalter, 1992). While other investigations of this nature indicated enhanced performance of reaction time following exercise intensity (McMorris & Keen, 1994).

In terms of the effect of exertion and fatigue on sport skills, McMorris, Gibbs, Palmer, Payne, and Torpey (as cited in Lyons, 2011, p. 47) investigated the impact of moderate and intense exertion on the sport-skill performance using soccer pass test. The experimental conditions were soccer performance at rest, following exercise at 70% and 100% of maximum power output (MPO). The results of this study suggested that the optimal soccer passing performance occurred at 70% MPO in comparison with rest condition and 100% MPO which showed an inverted-U effect on the tested passing task.

Exploring the effect of exercise intensity on attention as the major component of concentration more specifically, Sibley, Etnier, and Le Masurier (2006) reported that a 20-minute running and/or walking at moderate exercise intensity improved Stroop colour-word test performance. On the contrary, Al-Nakeeb and Lyons (2007) demonstrated that there were no differences in performance of Stroop test across exercise intensity conditions. Similar to Sibley et al. (2006), they studied the effect of exercise intensity on Stroop performance at rest condition, moderate (50% HRR) and high (80%HRR) exercise intensities while exercising on a cycle ergometer. However, the conclusive findings of some past studies suggested that high exercise intensity may lead to a significant deterioration in performance of sport skills and decline in attention (Lyons, 2011).

One of the most important factors that elite athletes have is the ability to predict movements more precisely in a wide variety of sports (Tenenbaum et al., 2000). With regard to the impact of exercise intensity on coincidence anticipation timing, Al-Nakeeb et al. (2005) compared low- and high-skilled performers' coincidence anticipation timing accuracy at rest condition, following moderate (70% HRR) and high (90% HRR) exercise intensities induced by rowing ergometer using bassin anticipation timer device. The analyses revealed that there were no differences between low- and high- skilled performers at rest, moderate and high exercise intensities in constant error, variable error, and absolute error. More recently, in a follow up study conducted by Al-Nakeeb and Lyons (2007), the impact of rest condition, moderate- (50% HRR) and high-intensity (80% HRR) exercises on coincidence-anticipation task (fine motor skill) were examined. The results indicated no differences across all experimental conditions (rest, moderate and high exercise intensities). In keeping with these outcomes, the work by Lyons (2011) also highlighted the fact that, in overall, high-intensity or intense exercise does not deteriorate coincidence anticipation timing performance. Nonetheless, he added the point that the impact of exercise intensities on performance are different regarding to the complexity of the task performed.

5.2 The Effects of Stimulus Speed & Gender on CAT

Exploring the effects of stimulus speed and gender on coincidence anticipation timing separately at different exercise intensities (rest, moderate, & high), six null hypotheses were proposed; a) there is no interaction between stimulus speed and gender on CAT at rest condition; b) stimulus speed does not have any significant effect on CAT in both male and female badminton players at rest condition; c) there is no interaction between stimulus speed and gender on CAT at moderate exercise intensity; d) stimulus speed does not have any significant effect on CAT in both male and female badminton players at moderate exercise intensity; e) there is no interaction between stimulus speed and gender on CAT at high exercise intensity; f) stimulus speed does not have any significant effect on CAT in both male and female badminton players at high exercise intensity. In the following section, these hypotheses will be discussed on both absolute constant error and variable error to indicate whether they are accepted or rejected in the present study.

Absolute Constant Error (|CE|): In terms of accuracy of coincidence anticipation timing scores, the results depicted that there was a significant interaction between stimulus speed and gender at rest condition showing more accurate performances for male players over females on CAT tasks at 1 mph stimulus speed (see Table 5.2). Significant stimulus speed main effect was observed at moderate exercise intensity indicating that overall male and female performances were more accurate at 5 mph stimulus speed in comparison with 1 mph speed. A significant main effect for gender at high exercise intensity was observed showing males with higher accuracy of CAT tasks. A number of paired-samples t-tests were done and finally the results revealed that females were significantly accurate at higher (5 mph) stimulus speed in comparison to low (1 mph) speed in both moderate intensity and rest condition, respectively. Finally, the third (c) and fifth (e) null hypotheses are accepted.

A number of paired-samples t-tests revealed that there were no significant differences between performance accuracy of males within 1mph and 5 mph stimulus speeds at rest condition. Nevertheless, the results depicted that females were significantly accurate at higher stimulus speed (5 mph) in comparison to low speed (1 mph). The results also showed that there was no significant difference in terms of accuracy of performance in males within 1 mph and 5 mph stimulus speeds at moderate exercise intensity. However, females had more accurate scores at 5 mph stimulus speed in comparison to 1 mph speed. Furthermore, there were no significant differences in performance accuracy of both males and females between rest condition and moderate exercise intensity. Paired-samples t-tests for high exercise intensity demonstrated that there were no significant differences between performance accuracy of both male and female players within 1 mph stimulus speed and 5 mph speed. In overall, there were no significant difference between performance accuracy of both males and females at high exercise intensity between rest condition and moderate exercise intensity.

Table 5.2 Summary of Significant & Non-Significant Results for Stimulus Speed & Gender

Error Measurements	Sources	Rest	Moderate	High
|CE|	SS × G Interaction	1: M>F	NS	NS
	SS Main Effect	NS	5>1	NS
	G Main Effect	NS	NS	M>F
VE	SS × G Interaction	1: M>F	NS	NS
	SS Main Effect	NS	5>1	5>1
	G Main Effect	NS	NS	M>F

Note. SS: Stimulus Speed; G: Gender; NS: not significant; 1: 1 mph stimulus speed; 5: 5 mph stimulus speed; M>F: males were more accurate/consistent than females; 5>1: participants were more accurate/consistent at 5 mph stimulus speed.

Variable Error: To consider the consistency of coincidence anticipation timing scores (see Table 5.2), the results revealed that, similar to |CE|, there was a significant interaction between stimulus speed and gender at rest condition indicating high consistency for males' scores on CAT tasks at 1 mph stimulus speed. There was also significant main effect for stimulus speed at moderate exercise intensity. Eventually, investigating high intensity exercise, results indicated that there was no significant interaction between stimulus speed and gender, but there were both significant main effects for stimulus speed and gender factors. A number of paired-samples t-tests indicated that males were significantly consistent at higher (5 mph) stimulus speed in comparison to low (1 mph) speed at moderate and high exercise intensities. On the other hand, females had significantly lower VE at faster (5 mph) stimulus speed compared to lower (1 mph) speed at rest condition and moderate exercise intensity. Finally, the results showed that in overall, females were significantly consistent at moderate exercise intensity when compared with rest condition. All in all, the third (c) and fifth (e) null hypotheses (e) are accepted.

A number of paired-samples t-tests indicated that there were no significant differences in performance consistency of males within two stimulus speeds at rest condition. Nevertheless, the results depicted that females were significantly consistent at higher (5 mph) stimulus speed in comparison to low (1 mph) speed. The results of t-tests for moderate exercise intensity revealed that there were significant differences in performance consistency of both males and females within 1 mph stimulus speed and 5 mph speed. Also, it was showed that the consistency of males' performances did not differ significantly between rest condition and moderate exercise intensity. Nonetheless, females had more consistent scores at moderate exercise intensity compared to rest condition. Additionally, the results revealed that there was a significant difference in performance consistency of males within two stimulus speeds showing more similar scores at faster stimulus speed (5 mph) at high exercise intensity. However, females did not differ in terms of consistency of performances across two stimulus speeds at high intensity. The results also indicated that in overall, there were no significant differences in performance consistency of both males and females between high exercise intensity and rest condition as well as high and moderate exercise intensities.

Few researches (Williams et al., 2002; Duncan et al., 2013; Duncan et al., 2015) investigated the impact of stimulus speed as another variable which may account for equivocal findings on coincidence anticipation timing performance in the literature. Actually, one key element highlighting these equivocal outcomes from the previous studies is the timing of the task performed. Although stimulus speed being highlighted as an important factor while examining the effect of exercise intensity, a number of investigations used one constant stimulus speed (Fleury & Bard, 1985). Based on previous studies (Sanders, 2011), it has been indicated that higher stimulus speeds were associated with poorer coincidence anticipation performance at rest condition. In terms of investigating the effect of stimulus speed on coincidence anticipation timing, Wrisberg, Hardy, and Beitel (1982) debated that lower absolute error and variable error would result from faster stimulus speeds (which produced late response) in comparison with slower speeds (which produced early response; as cited in Williams et al., 2002, p. 29).

The findings of present study in terms of stimulus speed and gender effect on coincidence anticipation timing indicated that female adolescents were significantly variable (less consistent) in comparison with male players while performing at slow stimulus speed (1 mph), but not at high (5 mph) speed only in rest condition. In other words, there were no significant differences between males and females' performance consistency at each stimulus speed in moderate and high exercise intensities. In addition, males were more accurate than females at low (1 mph) stimulus speed in comparison with high (5 mph) speed in rest condition and high exercise intensity.

In the study conducted by Williams et al. (2002) in terms of the impact of stimulus speed and gender on coincidence anticipation timing performance, the findings revealed that male participants were highly consistent (less variable) than females at low stimulus speed (6 mph), but not at fast speed (12 mph). Hence, the finding of present thesis is consistent with those of Williams et al. (2002) in terms of stimulus speed and gender effect on CAT. Williams and colleagues (2002) believed that coincidence anticipation timing appears to be refined with practice, sensitive to differences in gender, and adaptable to changes in environmental demands. Therefore, they debated that the response organisation (potential role of programming) differences between males and females on CAT performance observed in their study is based on ecological perspectives rather than information processing perspectives. The authors said that the control of response timing could be coordinated by combination of continuous processes of motor and perceptual responses. Finally, the authors concluded that although the outcomes confirmed the existence of a gender effect for variable error, the underlying reasons for poorer performance of females merit further studies.

In general, a large number of studies researching gender impact on cognitive and perceptual tasks indicated that males had more accurate and consistent performance than females (Williams et al., 2002; Sanders, 2011). Some researchers believed that these findings would result from reasons such as participation rates in sports with anticipatory demands (Petrakis, 1985), spatiotemporal skills or more conservative approach to responding by female participants (Schiff & Oldak, 1990), or even sociocultural variables (Sanders, 2011).

Stimulus speed is another variable which may account for equivocal results relating to coincidence anticipation timing performance. Consequently, one key element underlying the importance of the discrepant findings in terms of coincidence anticipation is the timing of performance. While some researchers (Al-Nakeeb & Lyons, 2007; Duncan et al., 2013) examined CAT performance and exercise simultaneously, other researchers (Lyons et al., 2008) assessed post-exercise CAT performances. In earlier studies of this nature, recovery from the previous exercise intensity was allowed to occur during performance of the criterion task because physiological changes quickly return to base values on exercise cessation. Therefore, it is obvious that if measurements are not taken immediately on exercise cessation, speed of recovery could affect the findings. In the research conducted by Lyons et al. (2008), CAT performance was examined immediately following exercise cessation and there was still evidence that recovery occurred over the 20 CAT trials. Hence, a suggestion emphasised more recently by Lyons et al. (2008) that more preferable arrangement may be to assess performance during exercise once a steady state has been reached.

In the research conducted by Meeuwsen, Goode, and Goggin (1995; as cited in Williams et al., 2002, p. 29), they used a pushing-button task to test participants' performance under different stimulus speeds. Although the hitting response was assumed to require more internal anticipation than the pushing-button response, the authors depicted that variable error reduced significantly at higher stimulus speeds.

5.3 The Effects of Exercise Intensity & Stimulus Speed on CAT

To investigate the impact of exercise intensity and stimulus speed regardless of gender of the participants, two null hypotheses were formulated; a) there is no interaction between exercise intensity and stimulus speed on coincidence anticipation timing; b) exercise intensity and stimulus speed do not have significant effects on CAT in badminton players. In the following section, these hypotheses will be discussed on both absolute constant error and variable error to show that if they are accepted or not.

Absolute Constant Error (|CE|): To consider the accuracy of coincidence anticipation timing scores of participants, the results indicated that there were neither significant interaction between exercise intensity and stimulus speed nor main effects for exercise intensity and stimulus speed (see Table 5.3). Paired-samples t-tests revealed that participants had significantly accurate CAT scores in moderate exercise intensity at faster (5 mph) stimulus speed in comparison with slower (1 mph) speed. As a consequence, both null hypotheses proposed are accepted here.

Table 5.3 Summary of Significant & Non-Significant Results for Exercise Intensity & Stimulus Speed

Error Measurements	Sources	Results
|CE|	EI × SS Interaction	NS
	EI Main Effect	NS
	SS Main Effect	NS
VE	EI × SS Interaction	NS
	EI Main Effect	NS
	SS Main Effect	5>1

Note. EI: Exercise Intensity; SS: Stimulus Speed; NS: not significant; 5>1: participants were more consistent at 5 mph stimulus speed.

Variable Error (VE): In terms of variability of data collected (see Table 5.3), the findings indicated that there was a significant main effect for stimulus speed showing that participants had more consistent scores at high (5 mph) stimulus speed rather than low (1 mph) speed. A number of paired-samples t-tests also showed that all the exercise intensity conditions were significantly lower variable (more consistent) at higher (5 mph) stimulus speed when comparing to slower (1 mph) speed. Eventually, only the first null hypothesis (a) was accepted.

More recently, research findings investigating the effects of different exercise intensities and exertion fatigue on coincidence anticipation timing performance revealed inconsistent and conflicting results. Shim and colleagues (2005) and Duncan and colleagues (2013) believed that this lack of consistency is partly due to the diversity of methodological differences in criteria and type of exercise intensity, stimulus speed, and characteristics of participant. A number of investigations (Al-Nakeeb et al., 2005; Al-Nakeeb & Lyons, 2007; Lyons et al., 2008) reported that exercise intensity does not affect coincidence anticipation timing performance. Nevertheless, some other researchers (Bard & Fleury, 1978; Fleury & Bard, 1985, 1987; Fleury, Bard, and Carrie` re, 1981; as cited in Lyons et al., 2008, p. 207) revealed little or no impact of exercise intensity on CAT tasks. On the other hand, the impact of stimulus speed has been investigated on coincidence anticipation timing performance as another factor affecting CAT performance. After reviewing the scientific literature on this topic, it seemed to be that there were few studies which examined the effects of different stimulus speeds on CAT performance. In spite of the acknowledged importance of stimulus speed while assessing the effect of exercise intensity on coincidence anticipation timing performance, a number of investigations have used a single stimulus speed (Duncan et al., 2013). In overall, there were a number of studies suggesting the fact that faster stimulus speed is associated with poorer coincidence anticipation timing performance at rest condition (Williams et al., 2002; Sanders, 2011; Duncan et al., 2015).

The findings of present thesis revealed that both exercise intensity and stimulus speed did not have any influence on coincidence anticipation timing performance regardless of gender of the participants. However, participants indicated more accurate and consistent CAT performances at moderate exercise intensity at faster stimulus speed (5 mph) in comparison with rest condition and high exercise intensity. Plus, there was just significant consistency at 5 mph stimulus speed.

Lyons and colleagues (2008) examined the effects of different exercise intensities on coincidence anticipation timing performance between experts and novices. The constant stimulus speed of 5 mph was used on bassin anticipation timer. Lyons and colleagues (2008) concluded that elite hurlers could maintain the ability of CAT at all exercise intensities, whereas, novice hurlers could do the best CAT performances at moderate intensity. Thus, this is partial support for current thesis outcomes. In the present thesis, whole participants showed more accurate and consistent CAT performances at moderate exercise intensity at faster stimulus speed (5 mph). Likewise, novices had more accurate performances at moderate exercise intensity at 5 mph stimulus speed in the studies by Lyons et al. (2008).

Duncan et al. (2013) researched the effects of exercise intensity and stimulus speed on coincidence anticipation timing task. The results revealed that high-intensity exercise of treadmill had negative influence on coincidence anticipation timing performance which was particularly observable while stimulus speeds were intermediate and fast (this is contradictory from results of present thesis). The findings also indicated that when stimulus speed was low, there were no differences in the accuracy of CAT scores within exercise intensities. However, when stimulus speed was set at an intermediate level (5 mph), the accuracy of performances were getting better at moderate exercise intensity. Hence, this supports the finding of present study that participants had more accurate and consistent CAT performances at moderate exercise intensity at 5 mph stimulus speed. Finally, Duncan and colleagues (2013) concluded that both exercise intensity and stimulus speed affect CAT performance with greater declines while exercising at high intense and faster stimulus speed.

CHAPTER VI

CONCLUSION AND RECOMMENDATION

The main purpose of present study was to investigate the effects of different exercise intensities and stimulus speeds on coincidence anticipation timing performance of both male and female adolescent badminton players. In this section, a general discussion regarding the findings of this study as well as the recommendations for the future studies will be presented.

6.1 General Conclusion

From a number of analyses, it seems to be that males were more accurate across all exercise intensities in comparison to their female counterparts at low (1 mph) stimulus speed. At high (5 mph) stimulus speed however, there was no significant difference between males and females in terms of accuracy and consistency of performances. It was also observed that female players were more accurate and consistent at high (5 mph) stimulus speed compared to low (1 mph) speed. Nevertheless, males were just consistent at 5 mph stimulus speed and there was no difference between performance consistency at 1 and 5 mph stimulus speeds.

On the other hand, the effects of stimulus speed and gender were examined between male and female badminton players. The results showed that males were more accurate and consistent than females at low (1 mph) stimulus speed in comparison with high (5 mph) speed at rest condition. In addition, males had more accurate and consistent CAT performances than females at high exercise intensity. At intense exercise, good performance of males can be accounted due to the physiological differences between males and females. It is clear that males can stand more intense exercise or fatigue conditions than females. All in all, although the findings of present thesis confirmed the existence of differences between male and female players under rest condition and high exercise intensity, the better understanding of underlying reasons for different performances of females than males deserve further studies.

The effects of exercise intensity and stimulus speed on coincidence anticipation timing were measured regardless of gender of the participants. The findings depicted that all participants were more accurate and consistent at high (5 mph) stimulus speed in comparison with low (1 mph) speed at moderate exercise intensity. There were neither interaction between exercise intensity and stimulus speed nor main effects for exercise intensity or stimulus speed. However, participants had more consistent CAT performances at high (5 mph) stimulus speed comparing to slow (1 mph) speed.

From the findings of present thesis it has been concluded that young female badminton players had some difficulties anticipating at low stimulus speed in rest condition and high exercise intensity compared to their male counterparts. The result of this study suggests that badminton coaches and trainers should make a training sessions of both male and female players practicing with each other at slow speeds.

6.2 Recommendation for Future Research

In this study, the participants responded to the stimulus by pushing a button on the bassin anticipation timer device. This pressing-button task is a sensory-oriented response consisting small motor component; therefore, sport specificity and ecological validity is not considered (needed in badminton) at present task. Therefore, the experimental design and measurement method of coincidence anticipation timing should be modified from laboratory-based to field-oriented measurement progress. For instance, badminton players should anticipate in a real court and paddle with wide range of arm motions.

Secondly, moderate (70% HRR) and high (90% HRR) exercise intensities may not induce the real amount of fatigue expected for this study due to the expertise and good fitness level of participants. By and large, all the participants should reach the steady state of exercise intensity while running on the treadmill and then remain for 5 or 10 minutes to induce the real fatigue.

Thirdly, the coincidence anticipation timing performance of both gender under different exercise intensities at faster stimulus speeds (such as 8 & 12 mph) is equivocal. Thus, it can be beneficial to conduct faster stimulus speeds under different exercise intensities to indicate the potential differences between males and females on CAT performances.

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APPENDICES

Appendix A: Ethical Committee Permission

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

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22.11.2014

Gönderilen : Prof. Dr. Sadettin Kirazci
Beden Eğitimi ve Spor Bölümü

Gönderen : Prof. Dr. Canan Sümer
IAK Başkanı Vekili

İlgi : Etik Onayı

Danışmanlığını yapmış olduğunuz Beden Eğitimi ve Spor Bölümü öğrencisi Foad Alaei'nin "Effect of Gender on Coincidence Anticipation Timing with Respect To Exercise Intensity and Stimulus Speed" isimli araştırması "İnsan Araştırmaları Komitesi" tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

22/11/2014

Prof.Dr. Canan Sümer
Uygulamalı Etik Araştırma Merkezi
(UEAM) Başkanı Vekili
ODTÜ 06531 ANKARA

Appendix B: Parent Consent Letter

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY
06531 ANKARA-TURKEY

Veli Onay Mektubu

Sayın Veliler, Sevgili Anne-Babalar,

Orta Doğu Teknik Üniversitesinde Beden Eğitimi ve Spor Bölümünde yüksek lisans öğrencisi olarak "Cinsiyet etkisi farklı egzersizlerde ve farklı uyarı hızlarında sezinleme zamanlarında" başlıklı yüksek lisans tezini yürütmekteyim. Araştırmamın amacı yaşları 11 ve 17 arasında olan kız ve erkek badminton oyuncularının farklı egzersizlerde (dinlenme, orta ve yüksek şiddete) ve farklı uyarı hızlarında (1 ve 5 mph) sezinleme zamanlarının farkına bakmaktır. Bu amacı gerçekleştirebilmek için çocuklarınızın testlerimize katılmaları ihtiyaç duyulmaktadır.

Bu çalışma içerisinde zamanı ölçmek için Sezinleme Zamanlayıcısı (Bassin Anticipation Timing); egzersiz şiddetini ayarlayabilmek için koşu bandı ve kalp atımlarını ölçmek için telemetrik Polar saat kullanmaktayız. Oğlunuz/kızınız koşu bandında sub-maksimal düzeyde egzersiz yapacak ve egzersiz sonrası sezinleme zamanları ölçülecektir. Çalışmaya katılım tamimiyle gönüllülük temelindedir. Çocuğunuzun katılmasına izin verdiğiniz takdirde çocuğunuz bir gün içinde sabah saat 11.00 akşam 5.00 kadar olçum testleri yapılacaktır. Ulaşım bizim tarafımızdan güvenli bir araçla sağlanacaktır. Test suresi içinde, kimlik belirleyici hiçbir bilgi istenmemektedir. Çocuğunuzun kaydedilen bilgileri kesinlikle gizli tutulacak ve sadece bilimsel araştırma amacıyla kullanılacaktır. Bu formu imzaladıktan sonra hem siz hem de çocuğunuz katılımcılıktan ayrılma hakkına sahipsiniz. Araştırmayla ilgili sorularınızı aşağıdaki e-posta adresini veya telefon numarasını kullanarak bize yöneltebilirsiniz.

Saygılarımızla,
Foad Alaei

Lütfen bu araştırmaya katılmak konusundaki tercihinizi aşağıdaki seçeneklerden size en uygun gelenin altına imzanızı atarak belirtiniz ve bu formu çocuğunuzla okula geri gönderiniz.

A) Bu araştırmaya tamamen gönüllü olarak katılıyorum ve çocuğum ....'nın da katılımcı olmasına izin veriyorum. Çalışmayı istediğim zaman yarıda kesip bırakabileceğimi biliyorum ve verdiğim bilgilerin bilimsel amaçlı olarak kullanılmasını kabul ediyorum.

Baba Adı-Soyadı .... Anne Adı-Soyadı ....
İmza .... İmza ....

B) Bu çalışmaya katılmayı kabul etmiyorum ve çocuğumun ....'nın da katılımcı olmasına izin vermiyorum.

Baba Adı-Soyadı .... Anne Adı-Soyadı ....
İmza .... İmza ....

Appendix C: Counterbalancing Table

<table>
<tr><th></th><th>Intensity</th><th>Speed</th></tr>
<tr><td rowspan="8">Participants</td><td>70%</td><td rowspan="2">1 – 5</td></tr>
<tr><td>90%</td></tr>
<tr><td>90%</td><td rowspan="2">1 – 5</td></tr>
<tr><td>70%</td></tr>
<tr><td>70%</td><td rowspan="2">5 – 1</td></tr>
<tr><td>90%</td></tr>
<tr><td>90%</td><td rowspan="2">5 – 1</td></tr>
<tr><td>70%</td></tr>
</table>

Appendix D: Data Collection Table

Trial	Speed	-/+	Msec	Trial	Speed	-/+	Msec
1				21			
2				22			
3				23			
4				24			
5				25			
6				26			
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Appendix E: Calculation Table

Age	HR_{rest}	HR_{max}	70% HRR	90% HRR
11 (132 month)				
12 (144 month)				
13 (156 month)				
14 (168 month)				
15 (180 month)				
16 (192 month)				
17 (204 month)				

Appendix F: Turkish Summary

TÜRKÇE ÖZET

CİNSİYETE BAĞLI OLARAK GENÇ BADMİNTON OYUNCULARINDA EGZERSİZ ŞİDDETİ VE UYARI HIZININ SEZİNLEME ZAMANINA ETKİSİ

GİRİŞ

Belli bir dereceye kadar, motor davranışları ve algısal yetenekleri yüksek düzeyde iyi bir performans yetkin motor becerileri yürütmek için (yani, alıcı isabet ve çarpıcı) hemen hemen tüm spor özellikle de gerektiren interceptive eylemlere ihtiyaç vardır (Mori, Ohtani, & Imanaka, 2002; Ak & Koçak, 2010; Akpınar, Devrilmez & Kirazci, 2012). Hızlı top ve raket spor oyuncuların çoğu, müdahale yakalamak veya uzmanlık alanında başarılı olmak için nihayet rakibin alanına amaçlanan yere göndermek için doğru pozisyonda ve zamanında topa vurmak ve beklenir. Aslında, topun yönü kontak pozisyonu ve inme zamanlaması dayanır. Daha doğrusu, sporcuların istenen konuma vurmak için ya da kesişim uzayda kesin hedef hakkında karar vermek tam yaklaşan topun yönünü ve hızını tahmin etmek yeteneğine ve kapasitesine sahip olmalıdır (Williams, Davids, Burwitz, ve Williams, 1994).

Zamansal Sezinleme Süresi (ZSS) bilişsel performans kavramları arasında en tartışmalı günlük yaşam yüzlerinden biridir. Aslında, hızlı bir yanıt (reaksiyon süresi) hem de interseptif işlemleri yapmak (alıcı ve isabet) doğru bir beklenti kullanılarak ihtiyacı vardır.

Bir uyaranın sağ nihai varış yeri tahmin ya da zamansal bilgi ve varış süresi ile ilgili uygun bir yanıtı koordine etmek için zaman ve mekan içinde nesneyi hareket altta yatan yetenek zamansal sezinleme süresi yeteneği olarak bilinir (Abernethy ve Wood, 2001; Lyons, Al-Nakeeb ve Nevill, 2008; Sanders, 2011; Duncan, Smith, Hankey, ve Bryant, 2014; Duncan, Stanley, Smith, Price, ve Wright, 2015).

Zamansal Sezinleme Süresi yeteneği (yanıt doğruluk) hedefe yaklaşan nesnenin geliş ve sanatçının tepkisi yürütme arasındaki zaman aralığında tutarsızlık tarafından değerlendirilmelidir (Ak ve Koçak, 2010). Ama burada soru şu ki nasıl tesadüf beklentisiyle değerlendirilmelidir? ZSS performansları doğruluğu normalde pek çok çalışmada Bassin Sezinleme Zamanlayıcısı (BSZ) cihaz tarafından değerlendirilmiştir (Lyons ve arkadaşları, 2008; Akpinar ve arkadaşları, 2012; Duncan, Smith, ve Lyons, 2013; Kim, Nauhaus, Glazek, Young, ve Lin, 2013). Bu düzenek, genel olarak, bir kontrol konsolu, bir yanıt anahtarı ve hareketinin taklit LED lambaları veya lambaları diyot bir doğrusal dizi olan bir ya da daha fazla ardışık pistleri oluşur. Lambaları seri olarak yandığında geçen lambası yanacak tahmin zaman, katılımcıların tepki düğmesine basın gerekmektedir.

Yaklaşan bir topun kapasitesini tahmin veya yaklaşan nesneler yürütme ve çevre eylemi (açık beceriler) sırasında tutarsız ve öngörülemeyen spor faaliyetlerine tepki olarak temel bir kavram gibi görünüyor. Ayrıca, bu tesadüf beklenti zamanlama yeteneği sporlarında önemli olan belirtilir hareket beceri kontrol sanatçısı tarafından ancak böyle futbol bir geçiş alırken ya da alıcı olarak çevreye tarafından belirlenen olmadığını belirsizlik oluşur bir hizmet tenis (Singer, Cauraugh, Chen, Steinberg, ve Frehlich, 1996; Duncan ve arkadaşları, 2013). Bu nedenle, beklenti dışarıdan tempolu spor açık beceriler yürütme açısından en önemli faktörlerden biridir (Williams, Katene, ve Fleming, 2002).

Spor dünyasında, zamansal sezinleme süresi yaygın sporcuların el-göz koordinasyonu ve yetenek tespiti açısından görsel doğruluğuna bunun tahmini ve yetenekli bireylerin seçimini test etmek amacıyla yapılmıştır (Ripoll ve Latiri, 1997). Sporcular, doğru ve başarılı bir tesadüf beklentisiyle zamanlama performansı tam zamanında nesne hareket beklentisiyle bağlıdır akılda tutmak gerekir, nesne ve nesne konumuna doğru düzgün vücut hareketleri tepki tamamlanmıştır ederken. Aksi takdirde, hareketli bir nesnenin yanlı veya yanlış algılama zamansal hata yol açabilir (Meeuwsen ve arkadaşları, 1997). Bir başka deyişle, gecikme ve beklentisiyle küçük bir değişiklik ya da yanlışlık spor puan kaybetmek yol açabilir (Ak ve Koçak, 2010).

Şu zamanlarda, araştırmacılar farklı yönlerini ilgili bu konunun anlayışımızda önemli iyileştirmeler yapmak için tesadüf beklentisiyle zamanlamasını keşfetmek için yöntemler muazzam sayıda kullandık. Buna göre, soruşturma çok sayıda çeşitli alanlarda etkisini incelenmiştir, örnekleri, cinsiyet farkı, beceri düzeyleri (uzman-acemi farklılıkları), yaşa göre spor faaliyetlerine ZSS yoğunluğu ve yorgunluk egzersiz. Zamansal sezinleme süresi yeteneği gelişmiş ya da bazı değişkenler ve faktörler tarafından kötüleşebilir. Bu olgunlaşma (yaş) ve deneyimsel faktörler kombinasyonu perceptuo-motora süreçleri etkileyebileceğini göstermiştir (Benguigui ve Ripoll, 1998).

Orada da bazı ön araştırmalar spor uygulama ile tesadüf beklentisiyle büyük bir geliştirme olduğunu iddia etti ve bunun yaşla birlikte sürekli olarak artırabilir (Ak ve Koçak, 2010; Akpınar ve arkadaşları, 2012). Aynı zamanda, açık becerileri sporcular (örneğin futbol, basketbol, voleybol) daha yüksek hızlarda, daha doğru ve kapalı becerileri sporcuları daha az değişken (örneğin koşu ve atletizm) yanı sıra sivil sporcular olduklarını kaydetti bassin zamanlayıcı cihaz (Benguigui ve Ripoll, 1998). Literatürde bu çabalara rağmen, bu konularla ilgili bazı cevapsız sorular hala vardır. Shim, Carlton, Chow ve Chae (2005) bilimsel literatürde ZSS eleştiri önceki araştırmaların çoğunluğu ya algı arasındaki ilişkinin ortadan kaldırılması üzerinde yapılan deneysel prosedürler (örneğin, yanıtların niteliği) bağlı olduğunu tartışılan ve bazı araştırmalarda cevabı.

Faktörler çok sayıda uzman acemi sporcular ve spor oyuncuları ayırtır. Müfettişler yetenekli oyuncular algısal yetenekleri, teknik ve taktik uzmanlık, bilişsel uzmanlık ve karar verme yüksek seviyede göstermek mümkün olabileceğini belirtti. Ayrıca, bazı uzmanlar genelde acemiler daha fazla dinamik görme keskinliği sahip olduğuna inanılmaktadır. Zamansal sezinleme süresi durumunda, uzmanlar da tam yerine daha az yetenekli oyunculara göre doğru, daha hızlı tahmin, önceden vurgulandığı gibi (Ishigaki ve Miyao, 1993). Açıkçası, bu yeteneği, uzman ve acemi oyuncular ayırt olabilir. Diğer bir deyişle, biz bu tesadüf beklenti zamanlaması elit bir oyuncu olmak sporcu geliştirme gerektiren kesinlikle gereklidir algısal beceriler biridir sonucuna varabiliriz.

YÖNTEM

Bu çalışmada yaşları 11 ve 17 arasında olan kız ve erkek badminton oyuncularının farklı egzersizlerde (dinlenme, orta ve yüksek şiddete) ve farklı uyarı hızlarında (1 ve 5 m/sn.) sezinleme zamanlarının farkına bakmaktır.

Bu çalışma içerisinde sezinleme zamanını ölçmek için Sezinleme Zamanlayıcısı (Bassin Anticipation Timing - Lafayette Instrument Co., Model 35575), egzersiz şiddetini ayarlayabilmek için koşu bandı ve kalp atımlarını ölçmek için telemetrik Polar saat kullanıldı.

Katılımcılar koşu bandında sub-maksimal düzeyde egzersiz yaptılar ve egzersiz sonrası sezinleme zamanları ölçüldü. Çalışmaya katılım tamimiyle gönüllülük temelindedir. Çocukların katılmasına izin verildiği takdirde, çocuklar bir gün içinde sabah saat 11.00 akşam 5.00 kadar olçum testleri yaptılar. Ulaşım güvenli bir araçla sağlandı. Test suresi içinde, kimlik belirleyici hiçbir bilgi istenmemekteydi.

Literatür (Lyons et al.,2008; Duncan et al., 2013) genelde kadın ve erkeklerin orta şiddette yapılan egzersizlerde ve düşük uyarı hızlarında aralarında performans farkı göstermez iken yüksek şiddetli egzersiz ve yüksek uyarı hızlarında sezinleme performanslarını farklı olabileceğini göstermektedir. Her ne kadar bu yönde bazı çalışmalar olsa da bir kısım çalışmaların sonucu ise farkın mevcut olmadığını göstermektedir.

Çalışmanız, katılımcıların fiziksel olarak koşu bandında test edilmelerini gerektirse de test protokolü itibari ile 100 % efor istenmemesi nedeniyle sağlığı tehdit edici unsur içermemektedir. Ayrıca, katılımcıların sporcu olmaları sebebi ile benzer durumlara uzun süredir maruz kalmaları sebebi ile fiziksel ve/ya ruhsal sağlığını tehdit edici ya da onlar için stres kaynağı olabilecek unsurları içermemektedır.

Sporcular performanslarını artırmak amacıyla sürekli olarak antrenman yaparlar. Antrenman planlanmasını etkileyen yaş, fiziksel uygunluk gibi birçok faktör vardır. Çalışma sonucunda elde edilecek bulgular ile antrenman planlanmasının yapılmasında cinsiyetlerin göz önüne alınması gerekeceği ortaya çıkacaktır.

BULGULAR

Bu çalışma esas olarak egzersiz yoğunluğu ve uyarıcı hız kadınlar ve erkekler arasında beklentisiyle performansını nasıl etkilediğini belirlemek için tasarlanmıştır. Daha yakından bakıldığında, zamansal sezinleme süresi konusunda, cinsiyetin etkisi ayrı ayrı egzersiz yoğunluğu hız uyarıcı sonra saygı ile her uyaran hızında egzersiz yoğunluğu ile bir kez incelendi. Ayrıca, zamansal sezinleme süresı performans katılımcıların yoğunluğu ve uyarıcı hızını egzersiz ile ilgili erkek veya kadın olup olmadığı göz ardı incelenmiştir. Bu bölümde, araştırma soruları ayrı ayrı bu çalışmada yanı sıra literatür doğrultusunda bulgular önerilen hipotezlerin göre ele alınacaktır.

Egzersiz Şiddeti Etkisi ZSS Üzerinde

Analizler bir dizi, bu erkeklerin düşük (1 mph) uyaran hızında bayan meslektaşları ile karşılaştırıldığında tüm egzersiz yoğunluklarının arasında daha doğru olduğunu görünüyor. Yüksek (5 mph) uyaran hızında Ancak, doğruluk ve performans tutarlılık açısından erkek ve kadınlar arasında anlamlı bir fark yoktu. Aynı zamanda kadın oyuncuların daha doğru ve düşük (1 mph) hıza oranla yüksek (5 mph) uyaran hızında tutarlı olduğunu gösterdi. Bununla birlikte, erkekler 5 mph uyaran hızında sadece tutarlı ve 1 ve 5 mil uyaran hızlarda performans tutarlılığı arasında hiçbir fark yoktu.

Uyarı Hızı Etkisi ZSS Üzerinde

Öte yandan, uyarı hızı ve cinsiyet etkileri erkek ve dişi badmintoncuların arasında incelenmiştir. Sonuçlar erkekler dinlenme durumuna yüksek (5 mph) hıza göre düşük (1 mph) uyaran hızında kadınlara oranla daha doğru ve tutarlı olduğunu göstermiştir. Buna ek olarak, erkekler yüksek egzersiz yoğunluğunda kadın daha doğru ve tutarlı ZSS performansları vardı. Yoğun egzersiz, erkeklerin iyi performans nedeniyle erkekler ve kadınlar arasındaki fizyolojik farklılıklar nedeniyle meydana edilebilir. Bu erkekler yoğun egzersiz veya yorgunluk koşullarında durumunda dişilerden daha fazla tahammül açıktır. Bulgular dinlenme durumuna ve yüksek egzersiz yoğunluğu altında kadın ve erkek oyuncular arasında farklılıkların varlığını doğruladı, ancak bütün olarak, kadınların yoksul performans altında yatan nedenler daha iyi anlaşılması ileri çalışmalara hak ediyor.

Egzersiz Şiddeti ve Uyarı Hızı Etkileri ZSS Üzerinde

Egzersiz yoğunluğu ve tesadüf beklentisiyle zamanlaması üzerinde uyarıcı hızının etkisi ne olursa olsun, katılımcıların cinsiyet ölçüldü. Bulgular, tüm katılımcıların orta egzersiz yoğunluğu düşük (1 mph) hız ile karşılaştırıldığında yüksek (5 mph) uyaran hızında daha doğru ve tutarlı olduğunu tasvir. Egzersiz yoğunluğu ve uyarıcı hızı ne egzersiz yoğunluğu veya uyarıcı hız için ana etkiler arasındaki etkileşim, ne vardı. Ancak, katılımcılar (1 mph) hıza yavaş karşılaştırarak yüksek (5 mph) uyaran hızında daha tutarlı ZSS gösterileri vardı.

TARTIŞMA VE SONUÇ

Zamansal sezinleme süresi yeteneği cinsiyet farklılıkları, birçok araştırmacının açısından erkek, kadın meslektaşları ile karşılaştırıldığında daha doğru ve tutarlı tahmin olduğunu ortaya koydu (Williams ve arkadaşları, 2002; Söğüt ve arkadaşları, 2009; Sanders, 2011). Onlar erkeklerde bildirilen daha doğru tesadüf umma zamanlama sonuçları nedeniyle motorlu faktörleri ve uzaysal becerileri (Schiff ve Oldak, 1990) ya da aynı zamanda spor tutulumu (Petrakis, 1985) farklılıklar olduğuna inanılmaktadır. Aksine, diğer araştırmacılar (Wrisberg ve Mead, 1983; Ripoll ve Latiri, 1997) erkek ve dişilerin zamansal sezinleme süresi performansı arasında anlamlı bir fark olduğunu tartıştılar.

Mevcut tez sonuçları erkek düşük (1 mph) uyaran hızında tüm egzersiz şiddetleri arasında anlamlı doğru olduğunu gösteren bir cinsiyet temel etkisinin olduğunu göstermiştir, ancak erkek oyuncuları iyi bir performans olsa yüksek hızda (5 mph) anlamlı değildi. Ayrıca, erkekler düşük (1 mph) uyaran hızında, kadın muadillerine göre dinlenme durumda daha benzer ZSS puanları vardı.

Son yıllarda, Lyons ve arkadaşları (2013) dinlenme durumu ve doğruluk ve erkek ve dişi tenisçiler arasında groundstroke tutarlılığına (orta ve yüksek) diferansiyel egzersiz yoğunluklarının etkileri araştırıldı. Sonuçlar orta (% 70 HR_{peak}) ve yüksek (% 90 HR_{peak}) kapsamında karşılaştırılabilir düzeyde yapılan hem erkek hem de kadın tenisçiler yoğunluk koşullarını egzersiz önerdi. Yazarlar orta ve yüksek yoğunluklu egzersiz koşullarında kadın ve erkek oyuncuların yanıtları benzerlik olduğu sonucuna varıldı. Genel olarak, çalışma egzersiz yoğunluğunun etkisi performansında benzer eğilimleri ile cinsiyet farklılıkları açısından şüpheli olduğunu göstermiştir. Bu tezin sonuç Lyons'un ve arkadaşları (2013) karşılaştırılır. çalışması, kısmen sırasıyla koşulu dinlenmek göre yüksek ve orta yoğunluktaki egzersizler hem kadın ve erkeklerde daha iyi performans için destek var. Lyons ve arkadaşları (2013) yorgunluk için ana etki bildirilmesine rağmen, cinsiyet temel etkisinin bu çalışmada gözlenmiştir. Öte yandan, mevcut çalışmanın sonuçları her iki cinsiyetten performans benzer bir eğilim bulundu erkekler ve kadınlar arasındaki farklılıklar açısında olanlar ve meslektaşları kısmen çelişkilidir. Bununla birlikte, erkek düşük (1 mph) uyaran hızında tüm egzersiz şiddetleri arasında anlamlı doğru ama o erkeklerin daha iyi performanslarina rağmen yüksek hızda (5 mph) anlamlı değildi.

Bilimsel literatürde, performans üzerindeki egzersiz yoğunluğunun etkisi açısından tutarlı sonuçlar ve çelişkili bulguların olmaması öncelikle egzersiz yoğunluğu için metodolojiler (kriterlerinin, yoğunluk miktarı, ve süresi) geniş bir yelpazede kullanarak eleştirilmiştir edilmiştir yoksul deneysel tasarımları yanı sıra kullanılan görevler (bilişsel, duyusal, ve motor) türleri önemli farklılıklar (Aks, 1998). Sonuç olarak, performans nedeniyle önceki egzersiz yoğunluğu kurtarma işlemi bazı çalışmalarda gerçekten emek durumda değerlendirilmemiştir olabilir.

Çelişkili sonuçlar için ikinci bir nedeni olarak, laboratuvar araştırma sıkı kontrol koşulları alışık olduğu tartışılan, bazı bilim adamları insan performansını etkileyen tüm farklı değişkenler kolaylıkla olmayan hangi performans alan bazlı çalışmalar üstlenmek için isteksiz olabilir (Noakes, 2000).

Üçüncü olarak, Aks (1998) ve Brisswalter ve arkadaşları (2002) deneysel sonuçların geniş çeşitliliği destekleyen önceki bazı araştırmaların en kritik sınırlamalar biri dikkate bireysel fiziksel uygunluk seviyesi farklılıkları almak için araştırmacılar tarafından başarısızlık olduğunu iddia etti. Sonunda, McMorris ve Keen (1994) çelişkili sonuçlar da tüm vücut hareketlerini ihtiyaç motor becerileri, bazı araştırmalarda ancak diğerlerinde egzersiz sonrası egzersiz sırasında değerlendirildi aslında kısmen olabilir görüşündedir. Özetle, sınırlılıkları ve eksiklikleri bir dizi literatürde performansı üzerinde egzersiz yoğunluğu/yorgunluk etkilerinin çalışmayı inceledikten sonra ortaya çıktı. Son olarak, bu egzersiz yorgunluk kaynaklanan performans düşüklüğü türleri ve kullanılan görevler, egzersiz süresi metodolojisi ve egzersiz yoğunluğuna göre farklılık olduğu bilinen görünüyor.

Birkaç araştırmalar (Williams ve arkadaşları, 2002; Duncan ve arkadaşları, 2013;. Duncan ve arkadaşları, 2015) literatürde tesadüf beklentisiyle zamanlama performansı şüpheli bulgular sorumlu olabilir başka bir değişken olarak uyaran hızının etkisini araştırdık. Aslında, önceki çalışmalarda bu belirsiz sonuçları vurgulayarak tek unsur yapılan görevin zamanlaması olduğunu. Egzersiz yoğunluğu etkisini incelerken uyaran önemli bir faktör olarak vurgulanmış sürat rağmen, araştırmalar numaralı sabit uyaran hızı kullanıldı (Fleury ve Bard, 1985). Yüksek uyarıcı hızları dinlenme koşullarında yoksul tesadüf umma performansı ile ilişkili olduğunu önceki çalışmalara (Sanders, 2011) dayanarak, bu belirtilmiştir. Zamansal sezinleme süresi üzerinde uyarıcı hızının etkisini araştıran açısından, Wrisberg, Hardy ve Beitel (1982) mutlak hata ve değişken hatası yavaş hızlarda ile karşılaştırıldığında daha hızlı uyaran hızları geç tepkisi üretti.

Uyaran hızı ve tesadüf beklentisiyle zamanlaması cinsiyet etkisi açısından mevcut çalışmanın bulguları kadın ergenler yavaş uyaran hızı (1 mph) de yaparken erkek oyuncularla karşılaştırıldığında anlamlı değişken (daha az tutarlı), ama yüksek değil belirtti (5 mph) sadece dinlenme durumda hız. Bir başka deyişle, orta ve yüksek yoğunluktaki egzersizler erkeklerin ve her uyaran hızında dişilerin performans tutarlılık arasında anlamlı farklılık yoktu. Buna ek olarak, erkekler dinlenme durumu ve yüksek egzersiz yoğunluğu yüksek (5 mph) hız ile karşılaştırıldığında düşük (1 mph) uyaran hızında kadın daha doğru idi.

Williams ve arkadaşları (2002) tarafından yapılan çalışmada uyaran hızı ve tesadüf beklentisiyle zamanlama performansı üzerindeki cinsiyet etkisi bakımından, bulgular erkek katılımcıların ancak hızlı (12 mph) bir hızda, düşük (6 mph) uyaran hızı de kadınlara göre (az değişken) son derece tutarlı olduğunu ortaya koymuştur. Bu durumda, bu tez bulgu, Williams ve arkadaşları kişilerce ile tutarlıdır. Uyarıcı hız ve ZSS cinsiyet etkisi açısından Williams ve arkadaşları (2002) bu tesadüf beklenti zamanlaması çevre taleplerindeki değişikliklere cinsiyet farklılıklara duyarlı ve uyarlanabilir, uygulama ile rafine görünüyor inanıyordu. Bu nedenle, tepki örgütü (programlama potansiyel rolü) yaptıkları çalışmada gözlenen ZSS performansı erkekler ve kadınlar arasındaki farklılıklar daha ziyade bilgi işleme perspektifler daha ekolojik bakış açıları dayandığını tartıştı. Yazarlar tepki zamanlamasının kontrol motor ve algısal yanıtların sürekli süreçlerin kombinasyonu ile koordine olabileceğini söyledi. Son olarak, yazarlar sonuçları değişken hata için cinsiyet etkisinin varlığını doğruladı, ancak kadınlarda daha kötü performans altında yatan nedenler ileri çalışmalar hak olduğu sonucuna vardı.

Genel olarak, bilişsel ve algısal görevlere cinsiyet etkisinin araştırma çalışmalarının çok sayıda erkeklerin kızlara göre daha doğru ve tutarlı bir performans olduğunu belirtti (Williams ve arkadaşları, 2002; Sanders, 2011). Bazı araştırmacılar, bu bulguların böyle katılımı beklenti talepleri ile spor oranları (Petrakis, 1985), uzaysal beceriler veya kadın katılımcıların (Schiff & Oldak, 1990), sosyokültürel değişkenlerin (Sanders tarafından yanıt daha muhafazakar bir yaklaşım olarak bazı nedenlerden kaynaklanan inanıyordu), ve yaşa bağlı nedenler (Dorfman, 1977).

Uyarıcı hız zamansal sezinleme süresi performansı ile ilgili belirsiz sonuçlar için sorumlu olabilir başka değişkendir. Sonuç olarak, tesadüf beklentisiyle açısından çelişkili bulguların önemini altında yatan bir anahtar unsur performans zamanlama. Bazı araştırmacılar (Al-Nakeeb ve Lyons, 2007; Duncan ve arkadaşları, 2013) aynı anda ZSS performansı ve egzersiz incelendiğinde, diğer araştırmacılar ZSS performans sonrası egzersiz değerlendirildi. Bu nitelikteki önceki çalışmalarda, bir önceki egzersiz yoğunluğu kurtarma fizyolojik değişiklikler hızla egzersiz bırakma bazal değerlere dönmek için kriter görevin ifası sırasında meydana bırakıldı. Bu nedenle, ölçümler egzersiz bırakma hemen alınmadığı takdirde, iyileşme hızı sorunlu olabilir açıktır. Lyons ve arkadaşları tarafından yapılan araştırmada. (2008), ZSS performansı hemen ardından egzersiz bırakma incelenmiş ve hala orada olduğunu kurtarma 20 ZSS çalışmalarda üzerinde meydana delil oldu. Bu nedenle, bir öneri Lyons ve arkadaşları (2008) tarafından son zamanlarda vurguladı. daha çok tercih düzenleme kararlı durum ulaşıldıktan sonra egzersiz sırasında performansını değerlendirmek için olabilir.

Meeuwsen, Goode, ve Goggin'in (1995) tarafından yapılan araştırmada, farklı hızlarda uyaran altında katılımcıların performansını test etmek için bir itme-düğme görevi kullanılır. Isabet yanıtı itme düğmeli yanıtı daha iç beklenti gerektirecek kabul rağmen, yazarlar değişken hata yüksek uyaran hızlarında önemli ölçüde azaltılmış olduğunu tasvir.

Daha yakın zamanlarda, farklı egzersiz yoğunluklarının ve tesadüf beklentisiyle zamanlama performansı üzerindeki efor yorgunluk etkilerini araştıran araştırma bulguları tutarsız ve çelişkili sonuçlar ortaya çıkardı. Shim ve arkadaşları (2005) ve Duncan ve arkadaşları (2013) tutarlılık bu eksikliği kriterleri ve egzersiz yoğunluğu, uyaran hızı tipi ve katılımcı özellikleri metodolojik farklılıkların çeşitlilik kısmen olduğuna inanılmaktadır. Soruşturma bir dizi (Al-Nakeeb ve arkadaşları, 2005; Al-Nakeeb ve Lyons, 2007; Lyons ve arkadaşları, 2008) egzersiz yoğunluğu zamansal sezinleme süresi performansını etkilemez bildirdi. Bununla birlikte, başka araştırmacılar (Bard ve Fleury, 1978; Fleury ve Bard, 1985, 1987; Fleury, Bard ve Carrie` re, 1981; Lyons ve arkadaşlari, 2008) belirtilen şekilde, çok az veya hiç etki ortaya çıkmadı. Öte yandan, uyaran hızı etkisi ZSS görevlerini etkileyebilecek bir başka faktör olarak tesadüf beklentisiyle zamanlama performansı incelenmiştir. Bu konuyla ilgili bilimsel literatürü inceledikten sonra, bu ZSS performansı farklı uyarıcı hızları etkilerini incelediler az sayıda çalışma olduğunu görünüyordu. Zamansal sezinleme süresi performansı üzerindeki egzersiz yoğunluğunun etkisini değerlendirirken uyaran hızı tanınmış önemi rağmen, araştırmalar bir dizi tek uyaran hızı kullanmıştır (Duncan ve arkadaşları, 2013). Genel olarak, bir dizi çalışma daha hızlı uyarıcı hızı dinlenme koşullarında yoksul tesadüf umma zamanlama performansı ile ilişkili olduğu gerçeğini öne vardı (Williams ve arkadaşları, 2002; Sanders, 2011; Duncan ve arkadaşları, 2015).

Mevcut tez bulguları egzersiz yoğunluğu ve uyarıcı hızı hem de ne olursa olsun, katılımcıların cinsiyet tesadüf beklentisiyle zamanlaması performansı üzerinde herhangi bir etkisi olmadığını ortaya koydu. Ancak katılımcılar dinlenme durumu ve yüksek egzersiz yoğunluğu ile karşılaştırıldığında daha hızlı uyaran hızı (5 mph) de orta egzersiz yoğunluğu daha doğru ve tutarlı ZSS performansları gösterdi. Ayrıca, 5 mph uyaran hızında sadece anlamlı tutarlılık yoktu.

Lyons ve arkadaşları (2008) uzmanları ve acemiler arasındaki zamansal sezinleme süresi performansı farklı egzersiz yoğunluklarının etkileri incelenmiştir. 5 mil sürekli uyaran hızı bassin umma zamanlayıcı kullanıldı. Lyons ve arkadaşları (2008), acemi atıcılar da orta şiddette en iyi ZSS performanslarını yapabileceği ise elit atıcılar, tüm egzersiz şiddetlerinde ZSS yeteneğini korumak sonucuna varmıştır. Böylece, bu kısmen geçerli tez sonuçları desteği olduğunu. Mevcut tezde, bütün katılımcılar daha hızlı uyaran hızı (5 mph) de orta egzersiz yoğunluğu daha doğru ve tutarlı ZSS performansları gösterdi. Aynı şekilde, acemiler Lyons ve arkadaşları (2008) tarafından çalışmalarda 5 mph uyaran hızında orta egzersiz yoğunluğunda daha doğru performanslar vardı.

Duncan ve arkadaşları (2013) zamansal sezinleme süresi görev egzersiz yoğunluğu ve uyarıcı hız etkilerini araştırdı. Sonuçlar koşu bandının yüksek yoğunluklu egzersiz uyaran hızları (bu mevcut tez sonuçlarından çelişkilidir) ara ve hızlı iken özellikle gözlemlenebilir oldu tesadüf umma zamanlama performansı üzerinde olumsuz etkiye sahip olduğunu ortaya koydu. Bulgular aynı zamanda uyaran hızı yavaş olduğunda, egzersiz yoğunluklarının içinde ZSS puanlarının doğruluğu hiçbir fark olmadığını göstermiştir. Uyarıcı hızı orta seviyede (5 mph) olarak belirlenmiştir. Ancak, performans doğruluğu orta egzersiz yoğunluğunda iyiye bulundu. Dolayısıyla, tüm bu katılımcılar 5 mph uyaran hızında orta egzersiz yoğunluğu daha doğru ve tutarlı ZSS performansları vardı. Bu çalışmanın bulguyu desteklemektedir. Son olarak, Duncan ve arkadaşları (2013) yüksek yoğun ve daha hızlı uyaran hızında egzersiz yaparken egzersiz yoğunluğu ve uyarıcı hızı hem büyük düşüşler ile ZSS performansını etkileyebilir sonucuna varmıştır.

Appendix G: TEZ FOTOKOPİSİ İZİN FORMU

<u>ENSTİTÜ</u>

Fen Bilimleri Enstitüsü □

Sosyal Bilimler Enstitüsü ■

Uygulamalı Matematik Enstitüsü □

Enformatik Enstitüsü □

Deniz Bilimleri Enstitüsü □

<u>YAZARIN</u>

Soyadı : ALAEI
Adı : Foad
Bölümü : Beden Eğitimi ve Spor

<u>TEZİN ADI</u> (İngilizce): The Effects of Exercise Intensity and Stimulus Speed on Coincidence Anticipation Timing with Respect to Gender in Adolescent Badminton Players

<u>TEZİN TÜRÜ</u> : Yüksek Lisans ■ Doktora □

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. □

2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. ■

3. Tezimden bir (1) yıl süreyle fotokopi alınamaz. □

<u>TEZİN KÜTÜPHANEYE TESLİM TARİHİ</u>: