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MODIFIED EQUIPMENT AND RULES INFLUENCE ON SKILL ACQUISITION AND PHYSIOLOGICAL DEMANDS IN BADMINTON AMONG CHILDREN



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ABDUL MU'IZ BIN NOR AZMI

SULTAN IDRIS EDUCATION UNIVERSITY

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THESIS SUBMITTED TO FULFILL THE REQUIREMENTS TO OBTAIN THE
DOCTOR OF PHILOSOPHY

FACULTY OF SPORTS SCIENCE AND COACHING
SULTAN IDRIS EDUCATION UNIVERSITY

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“Last but not least, I wanna thank me for believing in me. I wanna thank me for doing all this hard work. I wanna thank me for having no days off. I wanna thank me for never quitting throughout this whole journey. I wanna thank me for always being a giver and try to give more than I receive. I wanna thank me for tryna do more right than wrong. I wanna thank me for just being me at all times”.





ABSTRACT

The thesis aimed to examine the influence of modified badminton equipment and rules on skill acquisition and physiological demands among children. This study has two case studies. Study 1 aimed to examine the application of the body-scaling approach to modify racquets using arm length-to-racquet length ratios. Study 2 aimed to investigate the influence of modified equipment and rules based on the body-scaling approach on skill acquisition and physiological demands during the seven weeks of practice sessions. Twelve boys aged 13 to 14 years old with one to two years of badminton experience participated in both studies. In Study 1, the arm length of participants was measured to create arm length-to-racquet length ratios. During the match play and the badminton skills assessments, the participants utilized three types of racquets: racquets A (1.1:1.0), B (1.0:1.0), and C (0.9:1.0). In Study 2, participants were divided into two groups; Group A (n=6) utilized the modified equipment and rules (MEMR), while Group B (n=6) used standard equipment and rules (SESR) in the first practice period. In the second practice period, they changed the equipment and rules (i.e., counterbalanced design). The effectiveness of the participant's performance on the match play and physiological demands with both types of equipment were assessed in pretest, intermediate test, and post-test. The results in Study 1 showed that participants performed better in skills tests when using racquet B than racquets A and C, $p < .05$. The results in Study 2 showed that throughout the pre-, intermediate- and post-test, MEMR was more effective than SESR in every variable. The results of the transfer test showed that MEMR outperformed MESR, SEMR, and SESR in match-play variables and reduced physiological demands. This study demonstrates that adapting task constraints to children's physical abilities promotes the best learning environment for children to master the skills.





PENGARUH PERALATAN DAN PERATURAN YANG DIUBAHSUAI TERHADAP PEROLEHAN KEMAHIRAN DAN PERMINTAAN FISILOGI DALAM BADMINTON DALAM KALANGAN KANAK-KANAK

ABSTRAK

Kajian ini bertujuan untuk mengkaji pengaruh peralatan dan peraturan yang diubah suai ke atas pemerolehan kemahiran dan tuntutan fisiologi dalam kalangan kanak-kanak. Kajian ini mempunyai dua kajian kes. Kajian 1 bertujuan untuk mengkaji saiz raket dengan menunjukkan pendekatan skala badan untuk mengubah suai raket menggunakan nisbah panjang lengan kepada panjang raket. Kajian 2 bertujuan untuk menyiasat pengaruh peralatan dan peraturan yang diubah suai berdasarkan pendekatan penskalaan badan terhadap pemerolehan kemahiran dan tuntutan fisiologi sepanjang tujuh minggu sesi latihan. Seramai 12 orang lelaki berumur 13 hingga 14 tahun dengan pengalaman badminton satu hingga dua tahun telah menyertai kedua-dua kajian. Dalam Kajian 1, panjang lengan peserta diukur untuk mencipta nisbah panjang lengan kepada panjang raket. Semasa perlawanan dan penilaian kemahiran badminton, para peserta telah menggunakan tiga jenis raket: raket A (1.1:1.0), B (1.0:1.0), dan C (0.9:1.0). Dalam Kajian 2, peserta telah dibahagikan kepada dua kumpulan; Kumpulan A (n=6) menggunakan peralatan dan peraturan yang diubah suai (MEMR), manakala Kumpulan B (n=6) menggunakan peralatan dan peraturan piawai (SESR) dalam tempoh latihan pertama. Dalam tempoh latihan kedua, mereka telah menukar peralatan dan peraturan (iaitu, reka bentuk *counterbalanced*). Keberkesanan prestasi peserta pada permainan perlawanan dan tuntutan fisiologi dengan kedua-dua jenis peralatan dinilai dalam tiga ujian: ujian pra, ujian pertengahan, dan ujian pasca. Keputusan dalam Kajian 1 menunjukkan bahawa peserta menunjukkan prestasi yang lebih baik dalam ujian kemahiran apabila menggunakan raket B berbanding raket A dan C, $p < .05$. Keputusan dalam Kajian 2 menunjukkan bahawa sepanjang ujian pra, pertengahan dan pasca, MEMR adalah lebih berkesan daripada SESR dalam setiap pembolehubah. Keputusan ujian pemindahan menunjukkan MEMR mengatasi prestasi MESR, SEMR dan SESR dalam pembolehubah permainan perlawanan dan mengurangkan permintaan fisiologi. Kajian ini menunjukkan bahawa menyesuaikan kekangan tugas dengan kebolehan fizikal kanak-kanak menggalakkan persekitaran pembelajaran terbaik untuk kanak-kanak untuk menguasai kemahiran.





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CHAPTER 1

INTRODUCTION



1.1 Introduction

Skill acquisition is a complex process involving voluntary control of the body and joint movement to achieve the goal of action (Magill & Anderson, 2017). Traditional motor learning theories propose that human movement control is a complex adaptive system that consists of various interconnected subcomponents, especially in the human biological system (e.g., neuro-muscular system) (Renshaw, Davids, Newcombe & Roberts, 2019). According to Newell's (1986) constraints led-approach, skill acquisition is influenced by the interaction of the individual, task, and environmental constraints



(Davids, Button & Bennett, 2008). Individual constraints refer to an individual's physical (e.g., age, height, fitness, and hand span) and psychological (e.g., emotional, stress, and motivational) characteristics. Task constraints describe the equipment and rules used which influence the outcome of the action or task of an individual. Environmental constraints refer to external factors such as weather and gravity that can influence a learner's movement or action (Edwards, 2010).

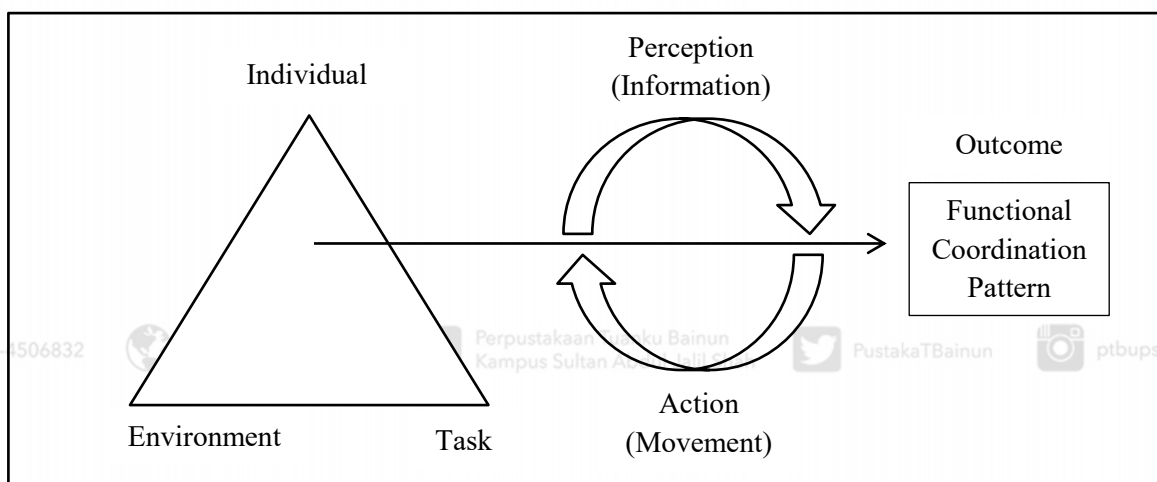


Figure 1.1. The interaction of constraints shapes the emergence of functional coordination patterns (Davids et al., 2008; Newell, 1986).

From the perspective of nonlinear dynamics as shown in Figure 1.1, the continuous interaction between an individual's unique intrinsic dynamics (individual constraints), the environment (environmental constraints), and specific task demands (task constraints) cause the system to self-organize into a temporarily stable state, resulting in the emergence of functional coordination patterns (Chow et al., 2011; Davids et al., 2008; Davids, Araujo, Seifert & Orth, 2015). Besides, these constraints can be



modified to influence the outcome of skill acquisition (Davids et al., 2008; Farrow & Reid, 2010). For instance, manipulating task constraints in children's sports by scaling crucial elements such as rules of the game, equipment, and the playing area is believed to be an effective strategy for improving performance development, optimizing functional movement patterns, encouraging decision-making, and developing movement creativity in sports (Buszard, Farrow & Reid, 2020; Buszard, Reid, Masters & Farrow, 2016; Fitzpatrick, Davids & Stone, 2018; Ortega, Blanca, Gimenez & Torres, 2020).

Scaling is the method of modifying or manipulating the task constraints, such as equipment, playing areas, and rules, in relation to children's physical size (Cronin, Harrison, Lloyd, & Spittle, 2017). The aim of scaling constraints is to help children precisely imitate the playing experience of an adult-like style by reducing the size of the equipment (e.g., reduce the racquet size in badminton) (Dancy & Murphy, 2020). Research in tennis showed that scaling methods by manipulating task constraints (e.g., modification of equipment and play area) leads to the employment of more desired techniques and greater levels of performance outcomes (Buszard, Farrow, Reid & Masters, 2014a; Fitzpatrick et al., 2018; Limpens, Buszard, Shoemaker, Savelsbergh, & Reid, 2018). Manipulating task constraints through modification of equipment, rules, and play areas have provided children with positive learning experiences and increased their motivation to engage in sports (Buszard et al., 2016; Buszard et al., 2020; Farrow & Reid, 2010; Limpens et al., 2018; Timmerman et al., 2015).



The insight of modifying the task constraints was developed based on the theoretical concept from the dynamic system theory called affordances (Fajen, Riley & Turvey, 2008). According to Gibson (1986), affordances are information sources about the characteristics of objects or environments that affect how they are used and what actions individuals can execute. Gibson (1986) related environmental features in terms of their relationship to individual physical characteristics (e.g., the size of the ball relative to the individual's hand size). It has been well established that the design of optimal learning environments (e.g., provide equipment, rules, and play areas that meet the physiological and psychological demands) can enhance skill acquisition (Buszard et al., 2020).

1.2 Background of the Study

Previous studies attempted to explain how sports scientists modified constraints in sports involving children and adolescents. Maturity and technical factors have been postulated as appropriate guidelines for modifying junior sports. Research in tennis has used racquet-to-racquet time (technical; Timmerman et al., 2015) and height (physical maturation; Limpens et al., 2018) to test the influence of scaling in junior sports. Recently, researchers in basketball also applied a similar method, evaluating the relative difference between basketball players' hand span and ball size (Gorman, Renshaw, Headrick, & McCormack, 2020). These examples provided an opportunity to create a more consistent approach to modifying junior sports.



Therefore, the body-scaling concepts, namely pi-ratios have been established to create systematic guidelines for modifying junior sports (Broadbent, Buszard, Farrow & Reid, 2021). Pi ratios refer to the ratio between a metric of a learner with a metric of a space or equipment (Broadbent et al., 2021; Van Der Kamp, Savelsbergh & Davis, 1998; Warren, 1984). Affordances were utilized in this concept to optimize the scaling of the constraints in junior sports, therefore assisting children in efficiently acquiring the skills (Gorman et al., 2020; Gagen, Haywood & Spaner, 2005). In the context of human movement, pi ratios can identify the key point at which a change in the person influences the action space (Newell, Scully, Tenenbaum & Hardiman, 1989). Some previous studies have used the concept of affordances to modify the equipment and play areas for children to learn sports skills.



In basketball, providing balls that fit children's hands facilitate them to move the ball in the same way as adults do, improving their learning abilities (Buszard et al., 2016a; Gorman et al., 2020). The use of a lighter ball also enables children to perform tasks more successfully (Afrouzeh et al., 2020; Arias, 2012; Arias, Argundo & Alonso, 2012a,b,c). In tennis, lowering the net height based on children's height resulted in participants playing more offensively, with more winners and shots made inside the baseline (Limpens et al., 2018). In badminton, manipulating the net height, the size of the racquet, and the size of the court leads to increased hitting opportunities and stroke effectiveness during matches among children (Azmi et al., 2020; Ortega et al., 2020).





Besides modifying the equipment and play areas, the game rules are also the constraints that can be manipulated to influence game conditions (Jaguszewski, 2020), players' conditions (Clemente et al., 2021), energy demands (Nakano, Fukashiro & Yoshioka, 2018), and psychological response (i.e., motivation) (Argudo, Garcia, Borges & Ruíz-Lara, 2021). The new rules seek to customize the game to the children and increase their engagement by adopting activities that are appropriate for their physiological, psychological, and technical characteristics (Garcia-Angulo et al., 2020). The rules modifications also affect fitness level, generally by increasing (Janowski, Zielinski, & Kusy, 2021) or decreasing it (Gastin, Allan, Bellesini & Spittle, 2017), besides reducing mental stress among players (Garcia-Calvo et al., 2021). Last but not least, the rules modifications can also influence the team's organizational structure and game plans (Perez-Ferreiros, Kalen & Rey, 2018).



Cronin et al. (2017) suggested that manipulating constraints through games modification (e.g., modifying rules and playing area) might facilitate junior athletes to enhance skill acquisition and physical fitness. Modifying constraints has been recommended as a means to effectively improve skills and fitness while also saving time by reducing overall training volume (Clemente, Martins, & Mendes, 2014; Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011). In badminton, players must perform quick changes of direction, lunges towards the net, jumps, and rapid arm movements from a variety of postural situations to prepare for strokes and anticipate shuttlecocks (Hong, Wang, Lam, & Cheung, 2014; Shariff, George, & Ramlan, 2009). These factors have also





influenced physiological demands (Phomsoupha & Laffaye, 2015). Several studies in badminton have examined the physiological demands by monitoring heart rate (HR) and rate of perceived exertion (RPE) as these variables were the most practical indicator to monitor during training and matches (Deka, Berg, Harder, Batelaan, & McGrath, 2017; Phomsoupha, Ibrahime, Heugas, & Laffaye, 2019; Sales et al., 2021). Due to the documented relationship between RPE and some objective physiological markers of intensity, such as HR and VO_2 max, rating of perceived exertion (RPE) is a reliable measure for exercise monitoring and prescription (Fernandez-Fernandez, Jose, Moya-Ramon, Cabello-Manrique, & Mendez-Villanueva, 2013).

1.3 Statement of the Problem



Until today, there is no specific equipment (e.g., racquet, court size, and net height) made based on children's physical size or age for them to utilize during badminton training and competition. According to the current rules of the Badminton World Federation (BWF) (2018), children are expected to play in the same conditions as adults. For adults, these playing conditions are acceptable forms of challenge that can be handled. The challenge becomes untenable when the individual is of smaller stature like children. With their shorter limbs (esp., arms), they require more energy and strength to generate enough force to execute strokes that would be able to propel the shuttle to achieve the desired objective (over the net / into the designated playing area). The constraints that come into children's play can be categorized into task constraints (e.g., equipment size and rules),





environment (e.g., type of court), and individual constraints (e.g., physiological demands). These constraints might hinder children's ability to train and compete in badminton. Therefore, modifications are necessary for badminton.

Several studies have explored numerous modified sports guidelines (e.g., modified equipment, rules, and play areas) (Azmi et al., 2020; Buszard et al., 2020; Buszard et al., 2016; Farrow & Reid, 2010; Gorman et al., 2020; Limpens et al., 2018; Timmerman et al., 2015). Nevertheless, only two studies in badminton have investigated the impact of modifying equipment and playing environments in real match situations. Azmi et al. (2020) examined the effect of manipulating the task constraints by reducing the net height (1.5m to 1.2m), scaling the racquet (40.0cm to 35.0 cm), and court size on children. The findings demonstrated that children recorded higher hitting opportunities and successful strokes when playing using modified equipment compared to when using standard equipment. A different study was performed by Ortega et al. (2020) compared the court dimensions (13.4 x 5.18m vs 11.88 x 5.18m), net height (1.55m vs 1.30m), and score system (21 points vs 15 points) between standard badminton and mini-badminton competition. The findings showed that playing in lower net height and smaller courts increased the frequency and variability of strokes and movement patterns.

However, there is a lack of empirical evidence regarding the approach or guidelines for modifying badminton equipment, especially the physical characteristics that previous studies have used as an indicator for modifying the equipment. In addition, past studies





only focused on the impact of modified equipment on skills acquisition, and no consideration was given to physiological demands during a match. In badminton, players must be able to move quickly and change direction during both short and long rallies, which requires higher physiological demands on aerobic and anaerobic systems for delivery and recovery throughout the play (Phomsoupha & Laffaye, 2015). This is an important variable that should be investigated, which Azmi et al. (2020) and Ortega-Toro et al. (2020) did not include in their research. Until now, there is a lack of studies that examined the effect of manipulating task constraints through modification of equipment and rules on physiological demands, especially in badminton. Consequently, it is unclear how modification of equipment and rules will influence the physiological demands among junior players during badminton training and competition.



Furthermore, the research in badminton mostly focused on the modification of equipment and play areas. Limited studies investigated the effects of modified game rules on the participants' skill acquisition and physiological demands. It is possible to give examples of modified rules in badminton, such as acquiring a point during a badminton game among children (e.g., scoring system – players will gain two points if they successfully hit the shuttle into a designated area without the opponent touching the shuttle and lose one point if the opponent made a mistake during a game). It has been reported that the rules modifications through implementing activities that suited physiological and technical skills can improve an individual's movement coordination patterns (Buszard et al., 2016; Garcia-Angulo et al., 2020).



Therefore, the study aimed: i) to determine the appropriate racquet size by applying a body-scaling approach (i.e., arm length-to-racquet length ratios) to modify racquet length, ii) to examine the influence of modified equipment and rules based on the body-scaling approach on skill acquisition and physiological demands during the seven weeks of the practice sessions.

1.4 Purpose of the Study

Study 1 aimed to determine the appropriate racquet size by utilizing a body-scaling approach (i.e., arm length-to-racquet length ratios) to modify racquet length. The study anticipated that children would perform well during skill testing and match play when using a modified racquet with a body-scaling approach since the technique maximizes affordances, making it easier for children to play badminton than with a standard racquet.

Study 2 aimed to investigate the influence of modified equipment and rules based on the body-scaling approach on skill acquisition and physiological demands during the seven weeks of practice sessions. This study hypothesized that playing with modified equipment and rules might facilitate children to acquire the skills effectively and lower the energy demands during the seven weeks of the practice sessions.

1.5 Research Objective

The objectives of the study were:

Study 1

1.5.1 To compare the task performance in the short serves, clear, and drop tests between racquet A (1.1:1.0 pi ratios), racquet B (1.0:1.0 pi ratios) and racquet C (0.9:1.0 pi ratios).

1.5.2 To compare the hitting opportunities, successful strokes, winning strokes, rally length, and unforced errors during the match-play between racquet A (1.1:1.0 pi ratios), racquet B (1.0:1.0 pi ratios) and racquet C (0.9:1.0 pi ratios).

Study 2

1.5.3 To compare the task performance in the short serves, clear, and drop tests between modified equipment with modified rules (MEMR) and standard equipment with standard rules (SESR) during the pre-test, intermediate test, and post-test.

- 1.5.4 To compare the hitting opportunities, successful strokes, winning strokes, rally length, and unforced errors between modified equipment with modified rules (MEMR) and standard equipment with standard rules (SESR) during the pre-test, intermediate test, and post-test.
- 1.5.5 To compare the heart rate (HR) and rate perceived of exertion (RPE) between modified equipment with modified rules (MEMR) and standard equipment with standard rules (SESR) during the pre-test, intermediate test, and post-test.
- 1.5.6 To compare the hitting opportunities, successful strokes, winning strokes, rally length, and unforced errors between modified equipment with standard rules (MEMR), modified equipment with standard rules (MESR), standard equipment with rules (SESR), and standard equipment with modified rules (SEMR) during the transfer test.
- 1.5.7 To compare the heart rate (HR) and rate of perceived exertion (RPE) between modified equipment with standard rules (MEMR), modified equipment with standard rules (MESR), standard equipment with rules (SESR), and standard equipment with modified rules (SEMR) during the transfer test.

1.6 Research Hypotheses

The null hypotheses of this study were:

Study 1

1.6.1 There is no significant difference in the task performance in the short serves, clear, and drop tests between racquet A (1.1:1.0 pi ratios), racquet B (1.0:1.0 pi ratios) and racquet C (0.9:1.0 pi ratios).

1.6.2 There is no significant difference in the hitting opportunities, successful strokes, winning strokes, rally length, and unforced errors during the match-play between racquet A (1.1:1.0 pi ratios), racquet B (1.0:1.0 pi ratios) and racquet C (0.9:1.0 pi ratios).

Study 2

1.6.3 There is no significant difference in the task performance in the short serves, clear, and drop tests between modified equipment with modified rules (MEMR) and standard equipment with standard rules (SESR) during the pre-test, intermediate test, and post-test.

- 1.6.4 There is no significant difference in the hitting opportunities, successful strokes, winning strokes, rally length, and unforced errors between modified equipment with modified rules (MEMR) and standard equipment with standard rules (SESR) during the pre-test, intermediate test, and post-test.
- 1.6.5 There is no significant difference in the heart rate (HR) and rate perceived of exertion (RPE) between modified equipment with modified rules (MEMR) and standard equipment with standard rules (SESR) during the pre-test, intermediate test, and post-test.
- 1.6.6 There is no significant difference in the hitting opportunities, successful strokes, winning strokes, rally length, and unforced errors between modified equipment with standard rules (MEMR), modified equipment with standard rules (MESR), standard equipment with rules (SESR), and standard equipment with modified rules (SEMR) during the transfer test.
- 1.6.7 There is no significant difference in the heart rate (HR) and rate of perceived exertion (RPE) between modified equipment with standard rules (MEMR), modified equipment with standard rules (MESR), standard equipment with rules (SESR), and standard equipment with modified rules (SEMR) during the transfer test.



1.7 Significance of the Study

The findings of this study may be significant to create guidelines to modify the equipment and rules in badminton based on the body-scaling approach since the previous studies provide too little information on how modification was made. The body-scaling approach could be assumed to be a suitable guideline for sports practitioners to alter equipment and regulations by implementing the size of equipment and rules according to an individual's physical measurement and capabilities. In this idea, affordances were used to maximize the scaling of constraints in junior sports, thus supporting learners in effectively acquiring the skills (Broadbent et al., 2021; Gorman et al., 2020). It is possible that creating a suitable learning environment by modifying equipment and rules for youth will facilitate the learning process and skill acquisition.

The findings have also been expected to enrich the existing body of knowledge and understanding from the perspective of physiological demands from the modification of equipment and rules, which may influence the training program in the future. The use of modified equipment and rules may maximize participation and opportunities for fitness among children. Children can utilize optimum energy expenditure according to their physical size, which may impact their training volume, and can train longer to acquire more skills efficiently. The findings will also help to expand the amount of data and information available in scaling badminton equipment and rules.





Besides, the research may provide the sports administrators such as the Badminton World Federation (BWF) or the Badminton Association of Malaysia (BAM) with a fresh viewpoint by developing new equipment and rules that can be tailored to an individual's age. In the future, we might see junior tournaments employ new equipment, play area, and rules designed specifically for the youth category. This might help children to play with greater ease, produce more desirable movement patterns, improving their skill acquisition and fitness during training. Importantly, by using this approach, badminton coaches can save the potential players that might not be selected due to their physical limitations (e.g., small stature).



The previous study has shown that children aged between 7 to 9 years old who used modified racquet and court size recorded higher hitting opportunities and successful strokes than children who used standard racquet and court size during mini-competition (Azmi et al., 2020). Using a smaller racquet and court size allows children to move more freely, making court coverage smoother and allowing them to reach the shuttle with ease. In comparison, using a standard racquet and court size, children need to produce more energy to make strokes and court coverage that might contribute to an earlier onset of exhaustion. This result has led to fewer hitting opportunities and successful strokes during competition.



1.8 Limitations

The researcher acknowledges that there are factors beyond his control that might have affected the result and conclusion of the study. The commitment and motivation of the participants in this study are key elements in data collection, which is crucial in performing motor skills during the study. The researcher also does not have control over the attitude of the participants during the practice sessions. Since the practice sessions in Study 2 have last seven weeks, few participants might be drop out of the study due to fatigue or lack of motivation. If many participants drop out during the study, it will be challenging for the researcher to collect the data again. Therefore, the researcher provided some extrinsic motivation (e.g., giving rewards or present) during the intervention to prevent the worst scenario.

To minimize fatigue and boredom throughout the intervention, the researcher devised an enjoyable training program that was tailored to the participant's physical abilities. Furthermore, to increase participants' motivation, the researcher gave a free racquet to all participants at the end of the study. Participants did not have to pay any cost during the intervention, such as court rental, drinking water, and shuttlecocks. The researcher has taken care of everything. Participants only need to be on time and enjoy the training session. Thus, participants gave 100% of their commitment to this study for the researcher to get the necessary data.

1.9 Operational Definitions

1.9.1 Standard equipment

The standard size for the racquet (68.0cm in length and 23.0cm in width – head), the court (6.1m x 13.4m), and net height (1.55m) that has been ruled by the Badminton World Federation (BWF).

1.9.2 Standard rules

According to the current regulations of the Badminton World Federations (BWF) for the scoring system, a point is awarded to a player if they win a rally, the opponent makes a mistake, or the shuttle is no longer in play because it contacts the surface of the court inside the opponent's court.

1.9.3 Modified equipment

The equipment size (e.g., racquet length, court size, and net height) was modified based on the body-scaling approach. The racquet length was modified using the participants' average arm (shoulder to hand) length. Meanwhile, the new measurement for court size and net height used the average height of the participants (Jackson, 2011; Limpens et al., 2018; Pirak, Nazarudin & Suppiah, 2020).

1.9.4 Modified rules

If a player wins a rally by shooting without allowing his opponent to touch the shuttles, he will receive two points. If the opponent touches the shot but fails to return it, one point only is added to the player's score. Any player who hits the shuttle outside the designated area and into the net will lose one point.

1.9.5 Physiological demands

The demands are placed on the body's energy systems (aerobic and anaerobic) to produce energy and assist recovery throughout the training and simulated matches as badminton is a sport that combines high-intensity short and lengthy rallies that require players to compete at their very best. Participants' heart rates (HR) and rates of perceived exertion (RPE) will be investigated in this study.

1.9.6 Skills acquisition

During a match, participants' abilities and capabilities in badminton will be examined. The parameters that will be measured in this study include hitting opportunities, rally length, successful strokes, winning strokes, and unforced errors.

1.9.7 Heart rate (HR)

The continuous high maximum HR (HRmax) during the game indicates significant stress on the cardiovascular system (Majumdar, 1997; Phomsoupha & Laffaye, 2015). The polar heart rate was used to measure the average heart rate of participants during the match-play.

1.9.8 Rate perceived of exertion (RPE)

This instrument will be used to record the participant's level of fatigue after the task on a 10-point scale, with "1" representing very minimal activity and "10" indicating maximum intensity (CR-10 Borg Scale; Borg, 1998).

1.9.9 Hitting opportunities

The number of strokes performed, regardless of the outcome (Azmi et al., 2020).

1.9.10 Successful strokes

The number of strokes that are successful hit over the net and in the designated playing area (Azmi et al., 2020).



1.9.11 Rally length

Total shots between opposing players, starting with a serve and ending when the point is won (total shots regardless of the outcome) (Torres-Luque et al., 2020).

1.9.12 Winning strokes

The strokes that hit successfully inside the court and does not offer the opportunity for the opponent to defend, resulting in a point for the player who executed it (Barreira & Chiminazzo, 2020).



1.9.13 Unforced errors

An unforced error is an error in a service or return shot that cannot be attributed to any factor other than poor judgment by the player and not because of the opponent's skill or effort (Paserman, 2007).





1.10 Thesis Outline

The objective of this introductory chapter has been to present the overview of the topic matter. The constraints-led approach serves as the theoretical framework to the basic understanding that skill acquisition is influenced by the interaction of three categories of constraints, individuals, tasks, and environmental constraints (Newell, 1986). This chapter also briefly states the importance of manipulating the task constraints through modifications of equipment and rules and its implication in skill acquisition. The specific objective, significance, and limitations of the study have also been outlined.

