International Journal of
Sports Science & Medicine

Research Article

Teaching Method Using Task Analysis to Boost Motor Skill and Badminton Forehand Overhead Clear Skill Learning -

Xiao Zhou[1,2], Kazuhiro Imai[1]* and Yuanchun Ren[2]

[1]*Department of Life Sciences, Graduate School of Arts and Sciences, The University of Tokyo, Komaba, Meguro ku, Tokyo, Japan*

[2]*Physical Education and Sports College, Beijing Normal University, Beijing, China*

***Address for Correspondence:** Imai Kazuhiro, Department of Life Sciences, Graduate School of Arts and Sciences, The University of Tokyo, 3-8-1, Komaba, Meguro-ku, Tokyo 153-8902, Japan, Tel: +813-545-46133; Fax: +813-545-44317; E-mail: imai@idaten.c.u-tokyo.ac.jp

Submitted: 07 July 2019; **Approved:** 23 July 2019; **Published:** 25 July 2019

Cite this article: Zhou X, Imai K, Ren Y. Teaching Method Using Task Analysis to Boost Motor Skill and Badminton Forehand Overhead Clear Skill Learning. Int J Sports Sci Med. 2019;3(2): 047-053.

ISSN: 2640-0936

ABSTRACT

This study aimed to adopt a teaching method using task analysis for badminton forehand overhead clear coaching experiment and evaluate the coaching effects. Sixty male participants (mean age: 14.6 years old) without badminton training experience were recruited. All the participants were assigned into two groups (30 participants in either group). Task analysis teaching method was applied in one group as task analysis group and conventional teaching method was applied in the other group as control group. Before the coaching experiment, there were no differences in physical fitness and badminton level between the two groups. Motor skills were evaluated using phase performance score. Badminton forehand overhead clear skills were evaluated using shuttlecock landing performance score. After the experiment, motor skills (25.8 ± 1.3 *vs.* 51.8 ± 3.7, $p < 0.01$) and badminton forehand overhead clear skills (22.2 ± 2.4 *vs.* 54.0 ± 6.4, $p < 0.01$) in task analysis group improved significantly. In control group, motor skills (25.2 ± 1.4 *vs.* 36.2 ± 2.8, $p < 0.01$) and badminton forehand overhead clear skills (23.2 ± 2.9 *vs* 50.8 ± 5.2, $p < 0.01$) also improved significantly. Two-way ANOVA analysis revealed that the coaching effects of task analysis group were significantly better than control group both of motor skills (51.8 ± 3.7 *vs.* 36.2 ± 2.8, $p < 0.01$) and badminton forehand overhead clear skills (54.0 ± 6.4 *vs.* 50.8 ± 5.2, $p < 0.05$). In conclusion, task analysis teaching method could boost badminton motor skill learning and develop motor skill abilities.

Keywords: Racket sport; Teaching method; Motor skill learning

INTRODUCTION

Forehand overhead stroke is the most important fundamental, powerful, and tactical stroke in badminton play [1-3]. The forehand overhead stroke is played with a full throwing motion which is difficult to maintain the smooth power delivery with kinematic chain during the skill performance [2,3]. According to the trajectory of shuttlecock, the forehand overhead stroke mainly divided into three categories, i.e. clear, smash and drop [3]. In badminton match, overhead stroke is 44.6% (17.0% clear, 13.8% smash and 13.8% drop) in all strokes of men's singles [4], and 57.0% (24.7% clear, 8.6% smash and 23.7% drop) in women's singles, respectively [4,5]. The forehand overhead stroke motion consists of four phases: preparation, acceleration, hit and follow-through. Irrespective of clear, smash or drop, a proper forehand overhead stroke motion is that all the three strokes look like the same until hitting the shuttlecock. Several events occur almost simultaneously during the forehand overhead stroke: weight shift, trunk rotation, lean backward, and upper limb extension [2]. An improper overhead motion generates kinetic differences that has been revealed not only negative consequences on performance [6-8], but also greater injury risk [9]. In most cases, badminton injuries were caused by falling or stumbling while retrieving a shuttlecock [10]. In badminton, upper limb injuries frequently occur in shoulder (36.9%) [11] that almost caused by overhead clear and smash [12].

Previous studies have utilized biomechanics to analyze badminton forehand overhead stroke motion in skilled players and demonstrated the foundational components including the range of motion of shoulder, elbow, wrist and trunk [6,13]. The body position in relation to the coming shuttlecock and the racket angle at the instant of hitting also influenced the forehand overhead stroke quality [14]. As for badminton teaching and training, some studies have adopted feedback methods in backhand short serve and forehand long serve instruction [15], badminton game play pedagogical model [16], and combined tactical and skill teaching on badminton performance [17,18]. Stretching exercises [19] and core stability training [3] have been reported that could facilitate to maintain optimum lower limbs dynamic balance so that improve badminton overhead stroke performance.

Task analysis is the process of breaking down complex tasks into subtasks such that the subtasks are easily understandable and manageable [20]. With task analysis, subtasks of motor abilities what are underlying, and foundational components of motor skill performance are assessed. Identification of motor abilities are involved in the successful performance of the subtasks. For example, to serve a tennis ball successfully, certain components of the skill must be performed properly. The first level of task analysis of the tennis serve is that identify the components (grip, stance, ball toss, backswing, forward swing, ball contact and follow through) of tennis serve, then identify the subtasks underlying motor abilities (multi-limb coordination, control precision, speed of arm movement, aiming, rate control, etc.) [21]. To correct the improper tennis serve performance, the subtasks as well as exercises to improve weak motor abilities of players could be adopted. Teaching method using task analysis is effective especially for novices to learn fundamental motions [22]. Nevertheless, there have not been any studies of teaching method using task analysis that combined badminton skill characteristics with badminton practices. This study aimed to adopt a teaching method using task analysis for badminton forehand overhead clear coaching experiment. After the coaching experiment, we evaluated the coaching effects in motor skill learning and forehand overhead stroke motion skill acquisition.

MATERIALS AND METHODS

Materials

Sixty male participants the age of 13-17 years old were randomly recruited from six high school physical education classes. All the participants did not have any experience of taking professional badminton training. This study was approved by Ethical Committee of the Graduate School of Arts and Sciences, the University of Tokyo, Japan (Notification Number 602-2, July 26, 2018).

Methods

We used a questionnaire to collect basic parameters of the participants including age, weight and height. Additionally, physical fitness tests of 50 meters run (s), standing broad jump (cm), 1000 meters run (min), and pull-ups (time) were collected. All participants were evaluated on two badminton skills: forehand long serve and forehand overhead clear. The participants were assigned into two groups: control group and task analysis group. Conventional teaching method was applied in the control group lesson and task analysis teaching method was applied in the task analysis group lesson.

The evaluation of badminton skills was modified from badminton forehand long serve and forehand overhead clear drills in "Badminton steps to success" [2]. To assess both of forehand long serve and forehand overhead clear skills, two categories of the evaluation were made: shuttlecock landing performance score to evaluate the accuracy of serve or clear, and phase performance score to evaluate motor skills. For forehand overhead stroke skill, the abilities of acceleration and follow-through motion were estimated by multi-limb coordination. The ability of hit the shuttlecock was estimated by visual tracking and eye-hand coordination. For shuttlecock landing performance score, the court was divided into zones, with scores ranging from 1 to 7 (Figure1), depending upon where the shuttlecock lands. Considered weak strength of the participants, the width of the longest zone was designed at 76 cm, and the other six zones were designed at the same width (66 cm). Ten trials for both of forehand long serve and forehand overhead clear were operated in the same gymnasium before and after the coaching experiment, respectively. The minimum score for each participant was 10 and the maximum score was 70. The physical fitness test and forehand long serve were executed to identify whether there were discrepancies between the two groups before the first lesson. Because forehand long serve skill was not taught during the experiment, we did not operate forehand long serve test after the experiment. The forehand overhead clear was done before the first lesson as a pre-experiment test and after the last lesson as a post-experiment test to evaluate the effects of teaching method on forehand overhead clear skill acquisition. The mean temperature measured of the tests was 23 ± 2°C, while relative humidity was 41 ± 2%. The badminton rackets with a lower tension of 21lb and the shuttlecocks what have an international speed metric of 3/77 were chosen.

Regarding the criteria of forehand long serve phase performance score, ten items were designed, including:

- Grip
- Put weight on the rear foot
- Place racket arm in backswing
- Cock wrist
- Transfer weight
- Rotate trunk
- Rotate forearm
- Hit the shuttlecock at about the knee level
- Cross racket in front of and over the opposite shoulder
- Roll hips and shoulder around

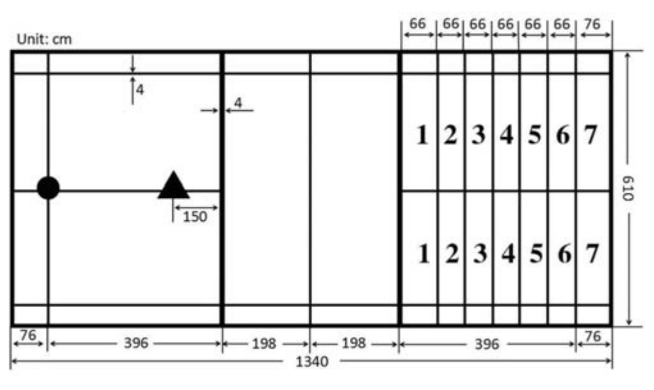

Figure 1: Badminton Court
● was the position where participants stood to hit a forehand overhead clear
▲ was the position where participants stood to perform a forehand long serve

Regarding the criteria of forehand overhead clear phase performance score, ten items were designed, including:

- Grip
- Body in balance behind the shuttlecock
- Lead elbow for arm extension
- Rotate trunk
- Pronate forearm
- Where to strike the shuttlecock in relation to the body
- Racket hand finishes palm out
- Cross racket to the opposite side of the body
- Swing the rear foot forward with scissors phase
- Recovery of racket body

Phase performance scores of each item ranged from 1 to 7 both of forehand long serve and forehand overhead clear. Three experienced and qualified badminton coaches who have an average badminton playing experience of 10.5 years, with an average of 5.3 hours of coaching per week were selected. Two of the coaches were selected randomly and evaluated the phase performance and marked the scores for the above 10 items before the first lesson, and due to the requirement for the consistent serve, the tests were administered by the third badminton coach for both of pre-experiment test and post-experiment test. The score of each item was marked based on 7 levels; 1 = incorrect, 2 = very inadequate, 3 = inadequate, 4 = moderate, 5 = developmental, 6 = adequate, 7 = very adequate. The mean scores of the two coaches' scores were defined as the phase performance scores, and the coaches also revealed deficits in each participant's motor skill ability using the criterion of forehand long serve and forehand overhead clear phase performance during the pre-experiment. For example, if a participant could not rotate trunk smoothly during acceleration motion of forehand overhead clear, then the participant was recorded as deficit in multi-limb coordination motor ability.

In the conventional teaching method for control group, the coaching programs were as follows (Figure 2):

1. The participants learned and practiced discrete forehand overhead clear phase
2. The participants learned and practiced integral forehand overhead clear motion
3. The coach organized the participants to practice forehand overhead clear. During the lesson, the coach gave the participants feedback and made corrections of inappropriate phases.

As for task analysis group, task analysis teaching method was applied. Before the coaching experiment, the coach analyzed and estimated the factors of the motor ability in each of forehand overhead stroke phase. The performance results of each participant in the pre-experiment test were analyzed in order to ascertain deficits in motor skill. The primary program was as follows: during the period of experiment the coach assigned the participant to practice discrete phase and integral motion, and then applied specific methods to overcome deficit motor skill during each lesson (Figure 3). For example, rope-skipping and burpee were applied to the participant who had a shortage of multi-limb coordination. Hit a hanging or a throwing shuttlecock was used to improve the abilities

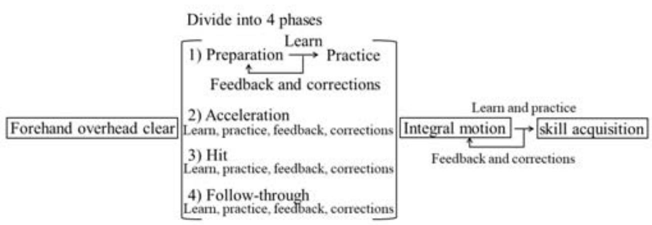

Figure 2: Conventional teaching method procedure for control group.

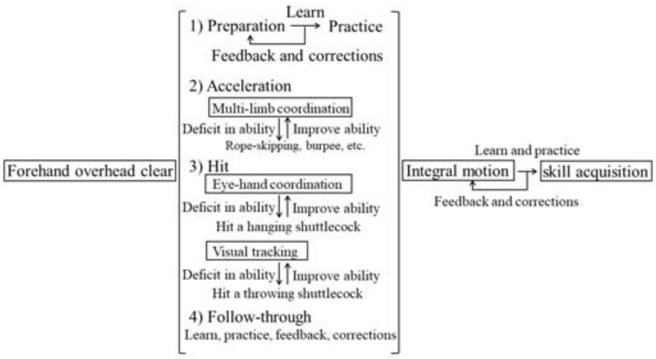

Figure 3: Task analysis teaching method procedure.

of visual tracking and eye-hand coordination. Using task analysis of badminton coaching, forehand overhead stroke was breaking down into 4 phases of preparation, acceleration, hit and follow-through, and 3 subtasks of multi-limb coordination, visual tracking and eye-hand coordination.

The coaching experiment in both groups took 9 weeks by the same coach who did not perform the evaluation in the experiment test. Two lessons were assigned every week and each lesson was scheduled for 45 minutes. SPSS was adopted for statistical analysis. We used Shapiro-Wilk test to examine normality of basic parameters (age, weight, and height), physical fitness tests (50 meters run, standing broad jump, 1000 meters run, and pull-ups), forehand long serve scores, and forehand overhead clear scores. Basic parameters and physical fitness tests did not normally distributed, while forehand long serve scores and forehand overhead clear scores distributed normally. Mann-Whitney U test was used for basic parameters and physical fitness tests analysis between task analysis group and control group before the experiment. In order to assess the effects of conventional teaching method and task analysis teaching method, a two-way Analysis of Variance (ANOVA) with repeated measures was adopted to evaluate the interaction between time and teaching methods. Post-hoc simple effects analysis was used to detect any differences in both groups between the various testing time. For each statistical analysis, differences were considered significant at $p < 0.05$.

RESULTS

Characteristics of the participants are shown in table 1. There were no statistical differences of age, height, and weight between task analysis group and control group. Data on physical fitness of the participants are shown in table 2. No differences were detected between the two groups in 50 meters run, standing broad jump, 1000 meters run, and pull-ups.

Data on phase performance of forehand long serve and forehand overhead clear is shown in table 3. Before the coaching experiment as pre-experiment test, there were no differences between task analysis group and control group both of forehand long serve phase performance score and forehand overhead clear phase performance score. Data on shuttlecock landing performance of forehand long serve and forehand overhead clear showed there were no differences between the two groups before the coaching experiment.

Results of the two-way ANOVA analysis for assessing the effects of conventional teaching method and task analysis teaching method are shown in figure 4 and figure 5. Regarding the phase performance to evaluate motor skill learning, average scores of all participants improved significantly from 25.5 (task analysis group: 25.8, control group: 25.2) before the first lesson to 44.0 (task analysis group:51.8, control group:36.2) during the coaching experiment. Additionally, a significant time main effect ($F_{1,58} = 1701.84$, $p < 0.01$, partial $\eta^2 = 0.97$) and a significant interaction effect ($F_{1,58} = 322.23$, $p < 0.01$, partial $\eta^2 = 0.85$) were observed. Post-hoc simple effects analysis revealed that the task analysis teaching group showed significantly better effects than the control group ($F_{1,58} = 336.09$, $p < 0.01$, partial $\eta^2 = 0.85$) through the coaching experiment (Figure 4).

The shuttlecock landing performance (Figure 5) to evaluate badminton forehand overhead clear skill learning was analyzed

Table 1: Characteristics of the participants.

	Task Analysis Group (n = 30)	Control Group (n = 30)	*p* value
Age (year)	14.6 ± 1.2	14.7 ± 0.9	>0.05
Height (cm)	171.5 ± 5.8	173.8 ± 4.3	>0.05
Weight (kg)	58.1 ± 8.6	58.2 ± 7.3	>0.05

Values are mean ± standard deviation
p value (Mann-Whitney U test), between task analysis group and control group.

Table 2: Physical fitness of the participants.

	Task Analysis Group (n = 30)	Control Group (n = 30)	*p* value
50 meters run (s)	7.6 ± 0.6	8.0 ± 0.9	>0.05
Standing Broad Jump (cm)	228.5 ± 22.3	220.2 ± 21.0	>0.05
1000 meters run (min)	4.2 ± 0.2	4.1 ± 0.3	>0.05
Pull-ups (time)	4.5 ± 3.5	5.7 ± 3.4	>0.05

Values are mean ± standard deviation
p value (Mann-Whitney U-test), between task analysis group and control group.

Table 3: Evaluation of forehand long serve and forehand overhead clear in pre-experiment test.

		Task Analysis Group (n = 30)	Control Group (n = 30)	*p* value
Forehand Long Serve	Phase Performance	20.8 ± 1.8	21.2 ± 2.5	>0.05
	Shuttlecock Landing Performance	24.7 ± 2.8	22.6 ± 2.5	>0.05
Forehand Overhead Clear	Phase Performance	25.8 ± 1.3	25.2 ± 1.4	>0.05
	Shuttlecock Landing Performance	22.2 ± 2.4	23.2 ± 2.9	>0.05

Values are mean ± standard deviation
p value (ANOVA), between task analysis group and control group.

by the two-way ANOVA. The average scores of all participants improved significantly from 22.7 (task analysis group: 22.2, control group: 23.2) before the first lesson to 52.4 (task analysis group: 54.0, control group: 50.8) during the coaching experiment. A significant time main effect ($F_{1,58}$ = 1392.09, $p < 0.01$, partial $\eta 2 = 0.96$) and a significant interaction effect ($F_{1,58}$ = 7.11, $p < 0.01$, partial $\eta 2 = 0.11$) were detected. Post-hoc simple effects analysis revealed that the task analysis teaching group showed significantly better effects than the control group ($F_{1,58}$ = 4.73, $p < 0.05$, partial $\eta 2 = 0.08$) through the coaching experiment.

DISCUSSION

Phase performance score connects with performer's motor skills and shuttlecock landing performance score connects with the accuracy of performer's badminton forehand overhead clear, that is, badminton forehand overhead clear skills. Both of conventional teaching method and task analysis teaching method were effective to improve motor skills (phase performance score) as well as forehand overhead clear skills (shuttlecock landing performance score). Furthermore, task analysis teaching method was more effective than conventional teaching method in improving motor skills and forehand overhead clear skills, especially motor skills.

Motor skill learning refers to the increasing spatial and temporal accuracy of movements with practice [23]. Practice and feedback are the main components underlying the behavioral approach to motor skill learning [21,24,25] that human could improve accuracy and consistency across practices, and cognition also affects motor skill learning [24,26]. Moreover, variable practices have effects on the central nervous system and brain plasticity [27] that could produce the most effectiveness to transfer motor learning performance [28]. Vision practice could improve the effectiveness of perception skill acquisition and development, especially for novices [29,30]. Motor abilities are sorted into two broad categories: perceptual motor abilities and physical proficiency abilities. In the two categories, several small abilities have been identified including multi-limb coordination, rate control, static strength, eye-hand coordination, and visual tracking [21].

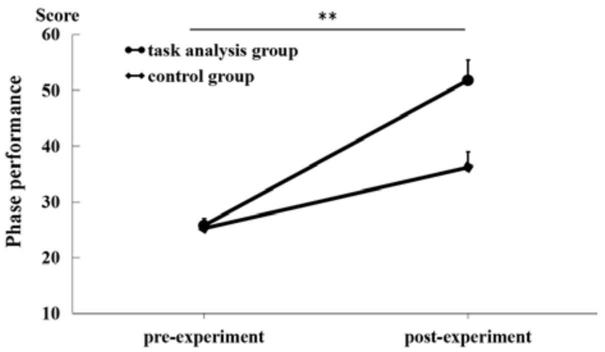

Figure 4: Phase performance during the experiment. The two-way ANOVA analysis revealed significant differences between groups in forehand overhead clear phase performance ($p < 0.01$). **p values < 0.01, between task analysis group and control group. The error bars represent one standard deviation from the mean.

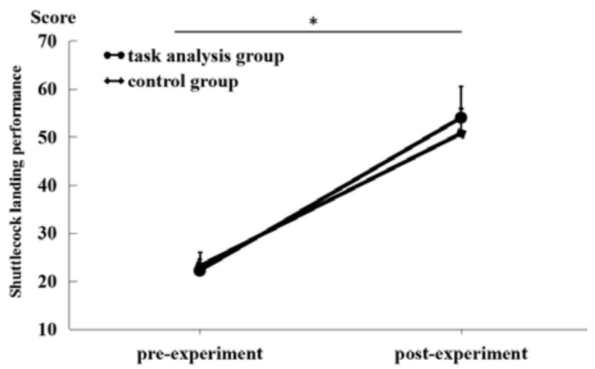

Figure 5: Shuttlecock landing performance during the experiment. The two-way ANOVA analysis revealed significant differences between groups in forehand overhead clear shuttlecock landing performance ($p < 0.05$). *p values < 0.05, between task analysis group and control group. The error bars represent one standard deviation from the mean.

Among 4 phases of preparation, acceleration, hit and follow-through, it is difficult for novices to learn acceleration phase and hit phase. In acceleration phase of baseball pitching, players should coordinate multi-limb at the same movements, i.e. transfer weight, trunk rotation, shoulder abduction, and shoulder horizontal adduction [31]. In acceleration phase of badminton, forearm rotation and nondominant arm downward movement occur simultaneously to produce the maximum absolute velocity to racket [2]. During hit phase, badminton players follow a moving shuttlecock visually and then decide to hit the shuttlecock. Multi-limb coordination is the essential ability during acceleration phase and visual tracking is the essential ability during hit phase. Eye-hand coordination is the ability to control the eye movement with hand movement [21]. Task analysis of badminton coaching in this study, forehand overhead stroke was breaking down into 4 phases of preparation, acceleration, hit and follow-through, and 3 subtasks of multi-limb coordination, visual tracking and eye-hand coordination. In addition, deficits in motor skill abilities of the participants were detected and improved.

Coaches' feedback and correcting practice improved the badminton performance of both groups in this study, which is consistent with previous badminton studies [32]. Generally, the procedure of motor skill learning for novices is from discrete motion to integral motion, but the major difference between the two groups is that task analysis teaching method focus on deficits in participants' motor skill abilities. After the experiment, task analysis group showed better effects, especially motor skill learning. We speculated that motor skill abilities (e.g. multi-limb coordination, visual tracking and eye-hand coordination) of the participants in task analysis group improved more efficiently than the control group.

Improper motions not only have negative effects on overhead motion performance, but also cause injuries. In baseball pitchers and in racquet players, improper overhead motions produced abnormal biomechanics that might cause upper limbs injuries, such as rotator cuff impingement or shoulder labral tear [33,34]. According to another biomechanics study of badminton forehand overhead stroke motion, some characteristics of forehand overhead stroke motion have been revealed. For example, the follow-through phase has been found that after contacting a shuttle, the phase occurs as elbow flexion reached the maximum angle of approximate 120°, and then decreased to approximate 80° to achieve follow-through [6]. The follow-through phase is important for overhead stroke players to dissipate excess momentum. The angle of elbow of the participants in the control group was greater than the task analysis group with upper limbs deviation. Upper limbs deviation may cause shoulder or elbow injuries because of shoulder adduction limitation and elbow hyperextension. Therefore, adequate motor skill acquisition is important for overhead stroke players to decrease the risk of injury. There were studies on the correlation between improper motion and injury/pain in racquet sports [34] that have demonstrated improper motions produce greater stress to body segment and increase the risk of injuries. Nevertheless, we have not found injury prevention studies on the correlation between correcting overhead motion technique and injury rates or pain complaints.

There are some limitations in the present study. First, the consistency of motor skills of badminton forehand overhead clear is still unknown. Consistency should be checked and revealed in future studies. Second, shuttlecock landing measures are inappropriate for assessing performance accuracy. We used shuttlecock landing performance score in this study. Using the trajectory of the shuttlecock [35] might evaluate performer's badminton forehand overhead clear skills more accurately. Third, visual tracking and eye-hand coordination were assessed by experienced coaches in this study. Real time eye tracking system might strengthen the assessment with objective data. Finally, although we have detected forehand overhead stroke motion of the two groups that the participants of the control group performed a deficit of limb control (greater elbow angle) during the follow-through phase (Figure 6), further biomechanics studies might be needed for more accurate information including shoulder and elbow kinematics.

CONCLUSION

This study showed that task analysis teaching method could facilitate novices to learn badminton forehand overhead clear. This teaching method is effective that not only learning badminton skills but also correcting improper phases and improving motor skills. Furthermore, task analysis teaching method should be adopted to boost the effectiveness of badminton learning. It is important for players to enhance badminton skills effectively and task analysis teaching method might be an approach to prevent badminton related injuries.

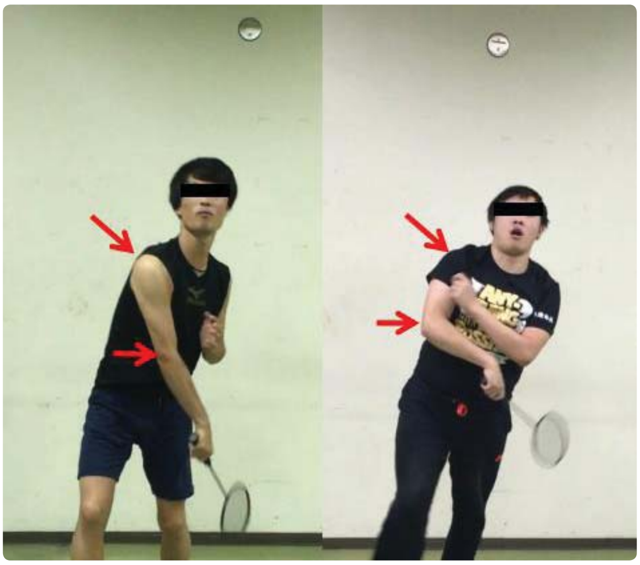

Figure 6: Analysis of forehand overhead stroke motion (follow-through phase). The left figure is the participant in control group who performed improper follow-through phase and the right figure is the participant in task analysis group who performed proper follow-though phase.

ACKNOWLEDGEMENT

We would like to thank coach Liming Ma and Xiaoli Xia for their contribution during the data collection phase.

REFERENCES

1. Lo D, Stark K. Sports performance series: the badminton overhead shot. Strength Cond J. 1991; 13: 6-15. https://bit.ly/30Q2btO
2. Grice T. Badminton: steps to success. Human Kinetics. 2008; 18-48. https://bit.ly/32RUtkX
3. Hassan IH. The effect of core stability training on dynamic balance and smash stroke performance in badminton players. IJSSPE. 2017; 2: 44-52. https://bit.ly/30TJplq
4. Phomsoupha M, Laffaye G. The science of badminton: game characteristics, anthropometry, physiology, visual fitness and biomechanics. Sports Med. 2015; 45: 473-495. https://bit.ly/2Ya0Oo1
5. Ming CL, Keong CC, Ghosh AK. Time motion and notational analysis of 21 point and 15 point badminton match play. S-SCI. 2008; 2: 216-222. https://bit.ly/2Y4cT35
6. Zhang Z, Li S, Wan B, Visentin P, Jiang Q, Dyck M, et al. The influence of X-factor (trunk rotation) and experience on the quality of the badminton forehand smash. J Hum Kinet. 2016; 53: 9-22. https://bit.ly/2YrxgX6
7. Sakurai S, Ohtsuki T. Muscle activity and accuracy of performance of the smash stroke in badminton with reference to skill and practice. J Sports Sci. 2000; 18: 901-914. https://bit.ly/2NnB7v8
8. Wang J, Liu W, Moffit J. Steps for arm and trunk actions of overhead forehand stroke used in badminton games across skill levels. Percept Mot Skills. 2009; 109: 177-186. https://bit.ly/2XXowsu
9. Fleisig GS, Barrentine SW, Zheng N, Escamilla RF, Andrews JR. Kinematic and kinetic comparison of baseball pitching among various levels of development. J Biomech. 1999; 32: 1371-1375. https://bit.ly/2y4Zsk1
10. Krøner K, Schmidt SA, Nielsen A, Yde J, Jakobsen BW, Møller-Madsen B, et al. Badminton injuries. Br J Sports Med. 1990; 24: 169-172. https://bit.ly/2K0Es3q
11. Shariff AH, George JR, Ramlan AA. Musculoskeletal injuries among Malaysian badminton players. Singapore Med J. 2009; 50: 1095-1097. https://bit.ly/2JLONkP
12. Whittam C. The impact of shoulder injuries on badminton player availability and performance. Bachelor Thesis, Cardiff Metropolitan University, Wales. 2013. https://bit.ly/30QW3S3
13. Tsai CL, Huang C, Lin DC, Chang SS. Biomechanical analysis of the upper extremity in three different badminton overhead strokes. In: ISBS-Conference Proceedings Archive. 2000; I: 1-1. https://bit.ly/30PtTXJ
14. Li S, Zhang Z, Wan B, Wilde B, Shan G. The relevance of body positioning and its training effect on badminton smash. J Sports Sci. 2017; 35: 310-316. https://bit.ly/2Y0nVX9
15. Tzetzis G, Votsis E. Three feedback methods in acquisition and retention of badminton skills. Percept Mot Skills. 2006; 102: 275-284. https://bit.ly/2JLMZZ8
16. Nathan S. Badminton instructional in Malaysian schools: a comparative analysis of TGfU and SDT pedagogical models. SpringerPlus. 2016; 5: 1215. https://bit.ly/32KZRWM
17. French KE, Werner PH, Rink JE, Taylor K, Hussey K. The effects of a 3-week unit of tactical, skill or combined tactical and skill instruction on badminton performance of ninth-grade students. J Teach Phys Educ. 1996; 15: 418-438. https://bit.ly/2JNtH5xc
18. French KE, Werner PH, Taylor K, Hussey K, Jones J. The effects of a 6-week unit of tactical, skill, or combined tactical and skill instruction on badminton performance of ninth-grade students. J Teach Phys Educ. 1996; 15: 439-463. https://bit.ly/2Guu9DQ

19. Jang HS, Kim D, Park J. Immediate effects of different types of stretching exercises on badminton jump smash. J Sports Med Phys Fitness. 2018; 58: 1014-1020. https://bit.ly/2JOZByJ

20. Srinivasan B, Parthasarathi R. An intelligent task analysis approach for special education based on MIRA. J Appl Logic. 2013; 11: 137-145. https://bit.ly/2YlTDxo

21. Magill RA, Anderson DI. Motor abilities. In: Motor learning and control: concepts and applications, New York: McGraw-Hill. 2013; 3: 59-65. https://bit.ly/32KOHRU

22. Siegel E. Task analysis and effective teaching. J Learn Disabil. 1972; 5: 519-532. https://bit.ly/2XZjD2c

23. Willingham DB. A neuropsychological theory of motor skill learning. Psychol Rev. 1998; 105: 558-584. https://bit.ly/2NFvnyo

24. Masaki H, Sommer W. Cognitive neuroscience of motor learning and motor control. J Phys Fitness Sports Med. 2012; 1: 369-380. https://bit.ly/2OpUCsi

25. Yanagihara D. Role of the cerebellum in postural control. J Phys Fitness Sports Med. 2014; 3: 169-172. https://bit.ly/32KPUZs

26. Sullivan KJ, Kantak SS, Burtner PA. Motor learning in children: feedback effects on skill acquisition. Phys Ther. 2008; 88: 720-732. https://bit.ly/2Yc0Snn

27. Imai K, Nakajima H. Exercise and nervous system. Dordrecht: Springer. 2009; 2: 299-318.

28. Wulf G. The effect of type of practice on motor learning in children. Appl Cogn Psychol. 1991; 5: 123-134. https://bit.ly/2JZ0DqJ

29. Vu Huynh M, Bedford A. An analysis of the skills acquisition trainer for badminton program: exploring the effectiveness of visual based training in sport. IJCSS. 2011; 10: 5-17. https://bit.ly/2YnYfCX

30. Bijanrajaeian MP, Mousavi MV. The Effect of visual practices on vision and movement performance of novice athletics in badminton sport. Bull Environ Pharmacol. Life Sci. 2014; 3: 114-118. https://bit.ly/2JQdZXz

31. Fortenbaugh D, Fleisig GS, Andrews JR. Baseball pitching biomechanics in relation to injury risk and performance. Sports health. 2009; 1: 314-320. https://bit.ly/2LGi823

32. Singh G, SINGH Y. Effects of different feedback methods on badminton skills learning. JPES. 2011; 11: 245-248. https://bit.ly/32Nrmiz

33. Olsen SJ, Fleisig GS, Dun S, Loftice J, Andrews JR. Risk factors for shoulder and elbow injuries in adolescent baseball pitchers. Am J Sports Med. 2006; 34: 905-912. https://bit.ly/2M91asM

34. Jayanthi N, Esser S. Racket sports. Curr Sports Med Rep. 2013; 12: 329-336. https://bit.ly/2JLvd8i

35. Vial S, Cochrane J, Blazevich AJ, L Croft J. Using the trajectory of the shuttlecock as a measure of performance accuracy in the badminton short serve. Int J Sports Sci Coach. 2019; 14: 91-96. https://bit.ly/2OdVC2R