APPLYING SENSORS TO INVESTIGATE GENDER DIFFERENCES IN BEGINNING TENNIS PLAYERS

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ABSTRACT

This study utilized sensors to investigate how females and males might perform and reflect differently on their tennis skills in a beginner class. A quasi-experimental design was conducted in this study to investigate the learning outcome of using tennis sensors. Two classes of students enrolled in a college physical education course participated in this study. One class of the students, who applied tennis sensor and reflective strategy, served as the experimental group; the other class using traditional instructional method served as the control group. The end-of-semester achievement test results showed that students in the experimental group performed as well as those in the control group. However, the experimental group performed a relatively smooth swing pattern and had better sensor-collected shot-data scores than those of the control group. As to gender effects, female students benefited more from using sensors when learning backhand groundstrokes, as compared to those not using. Male students tended to perform better on timing, swing speed, and spin level on making shots than those of the female students. The most common skill problems for both genders were maintaining balance and shifting the center of gravity of the body while hitting the balls. While viewing their own filmed practice videos, both gender of students reflected mostly on the key tennis techniques taught in the class; however, additionally, male students were more likely to refer to expectations or emotions regarding to their performance but the female students tended not. This study also showed that the sensors could be a useful tool in facilitating the analysis of tennis beginners' performance and in assisting their learning of key techniques. Future studies should use the sensors to collect data from a large sample of tennis beginning players so that the differences between genders could be thoroughly examined and analyzed. In addition, how to improve the instructional approach while using sensors in class to better fit both male and female students' needs is another critical issue in this field.

KEYWORDS

Sensors, Reflection, Gender, Tennis, Beginners

1. INTRODUCTION

Gender effects exist on student's performance on motor skills acquisition as well as sports activities, and tennis is usually the case (Krumer, Rosenboim, & Shapir, 2016; Thomas & Thomas, 1988). Previous study showed the gender difference exists not only on novice learners but also in professional players. Take tennis, for example, top male players showed higher Ace, 1st and 2nd serve points won, and fastest serve speed than female players (Chao & Wang, 2015). What causes these difference has been investigated for a long time, and physical limitations, as well as the psychological tendency, are two main reasons attribute to a gender difference in sports learning (Vilhjalmsson & Kristjansdottir, 2003). Generally, the physical difference includes height, body mass index (BMI), and muscular endurance and so on; those biological factors benefit males in strenuous activities. In addition, males' greater interest in sport may also affect their sport and physical activity involvement. Except to the difference in external performance, different psychological tendencies will also attribute to a diversity quality of reflections. Thus, how to identify the differences between genders in sport learning is critical in physical education.

Tennis is one of students' favorite physical education (PE) classes in college, but as it requires a high level of skill, such as the full-body coordination and timing of movements, beginners often find it difficult to master. How to improve the effectiveness of learning in group tennis class is a big challenge for college teachers. Feedback and modeling, are long recognized as effective approaches in motor skill acquisition

(Emmen, Wesseling, Bootsma, Whiting, & Van Wieringen, 1985; Hanrahan, Pedro, & Cerin, 2009; Hebert & Landin, 1994). Good feedbacks could provide knowledge about the correctness of movement, and enable learners to better clarify how to correct their movement leads to greater skill acquisition (Schmidt & Wrisberg, 2004). Modeling which serves as a standard of correctness helps learners to develop a cognitive representation and to regulate their movement, are particular benefits in the development of movement pattern early in learning (Magill, 1993). Thus, through demonstration of the correct technique by the instructor for modeling and provide verbal feedbacks according to learner's performance was the most common instructional approach in PE class. However, with relatively short practice phase under the group learning context, lead to the difficulty to provide sufficient feedbacks for each student by one instructor, and usually hard to improve the learning performance effectively as well (Lee, Keh, & Magill, 1993). Thanks to the progress of technology, recording a video is easier than ever before, more research related to skill acquisition applied video feedback while learning and got positive results (Palao, Hastie, Cruz, & Ortega, 2015; Zheng, 2013). The expert's demonstration video could play the role of modeling, and the record of learners' practice video provides visual feedback help them to better clarify their defects. Although the research supporting the potential benefits of video-feedback is vast, the effect of video-feedback in tennis learning is still questionable. Emmen et al. (1985) investigated the effects of video modeling and video feedback on the learning of tennis service by the novice and found no clear advantages while comparing with the traditional teaching approach. The possible reason might be due to the video display only provides knowledge of performance (movement information) but no knowledge of results (information about the outcome of service). In this end, learners have to notice if the ball was hit well or not through eye observation, lack of precise hitting data, and affect the efficiency of movement correction. In addition, the relatively long period of per week practicing sessions may have interfered the retention of the relevant cues available in videos. Thus, how to add the information of hitting outcome and extend the memory during non-practicing periods were the critical challenges to apply video-feedback in motor skill or tennis learning.

Many sensors have commercially available for tennis training in this decade. Using sensors to observe athletes' movements and the way they performed can provide useful information for training demands, and is a long-term endeavor in sports technology. The ability to detect and record each shot with precise hitting data can make up the lack of outcome information in traditional video-feedback instructions, in addition, the objective data also benefits the efficiency of learning performance analysis for educators. Apart from this, self-reflection can improve motor skill acquisition and help students to become more aware of their strengths and weakness, might be useful to extend the memory of learning (Jonker, Elferink-Gemser, de Roos, & Visscher, 2012). Most studies applied video-feedback in skill learning merely provides the instructor or learner's visual information (Emmen et al., 1985; Palao et al., 2015; Zheng, 2013), and considerably less research has applied video together with sensor data. Besides, how the sensor data may affect students' reflection process is not clear in the literatures. This study applies tennis sensors to record students' practice video together with their shoot-data. The videos provided both visual information of their movement and the embedded shooting data (impact spot, swing speed, ball speed and level of ball spin) of each shot, which facilitated students' reflection on their movement and making shots, and in turn, lead to better skill acquisition.

In this study, we utilized tennis sensors to assist beginners learning basic skills and to help us collecting shot-data from the students for performance analysis. The aim of this study is to investigate the gender differences of beginning tennis players in term of their skill performance when using sensors, their ways of hitting of balls, as well as their reflections on performance.

2. METHODOLOGY

An experimental design was conducted in this study to investigate the effects of utilizing sensors to assist the beginning tennis players learning key skills. In addition, the sensors were used to help analyzing how male and female students performed differently when hitting balls, and how they reflected differently on their skills. The participants of this study were two intact classes of college students enrolled in a beginner tennis course. One class served as the experimental group, which applied tennis sensor and reflective activities in the class. The other class using traditional instructional approach served as the control group. After excluding students with high rates of absenteeism, the experimental group was comprised of 25 students (10 males,

15 females); the control group also numbered 25 (18 males, 7 females). Classes were held once a week for 18 weeks, two hours per session. The instructor, course content (include instructor's demos), teaching schedule, and two TAs were the same for both groups. The only difference was that students in the experimental group were able to view their own practice videos, and were required to answer additional two self-reflection questions on the online course management system (Moodle). The first question is "What skill-related problems have you experienced in class this week?"; the second question is "Write down the areas in which you feel that improvement could be made".

In this study, we chose the Sony Smart Tennis Sensor for our experiment (Figure 1(a)). While syncing the sensor with a mobile device and select the "Live Mode Video" feature on the corresponding app, it could record the play data together with the video (Figure 1(b)). We use the ASUS Transformer Pad TF701T tablet computer to incorporate with the sensors and record both instructor's demos and students' practice videos. Each clip enables students to watch the form and shot placement in relation to their shot data. The achievement test was based on the Groundstroke Accuracy Assessment of the International Tennis Number (ITN) scoring standards (ITF, 2004). Both forehand and backhand groundstrokes performance were assessed, each was categorized into crosscourt and down the line shots. Five shots apiece for each of the four skills tested, for a total of twenty shots altogether. Each shot was assessed for accuracy, power, and stability; scores for each shot ranged from 0 to 7. In addition to the scores, we also record each student's video and shot-data during the test in both groups, and the clips were used to analyze how students performed differently. Finally, a total of six weeks of reflective activities which focused primarily on the forehand and backhand shots were collected to investigate how males and females reflect differently.

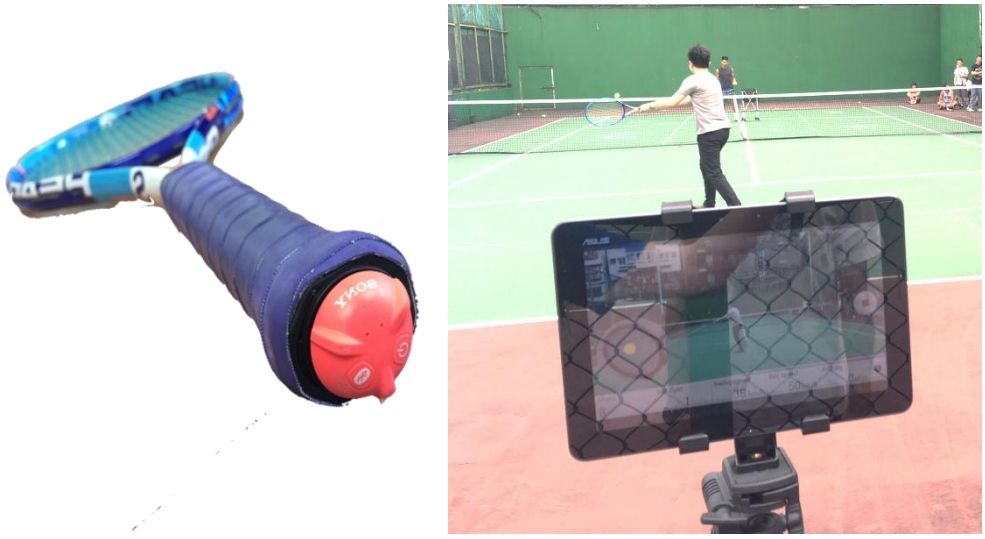

Figure 1. (a) A Racket attached with a Sensor; (b) A Tablet, Synced with the Sensor, is filming a Student's Practice

3. RESULTS

Data collected for analysis includes students' scores and recorded videos in the end-of-semester ITN test, and the experimental group's reflection on the Moodle.

3.1 How Females and Males Achieved Differently When Using Sensors?

The descriptive statistics showed that students in the experimental group had higher scores compared to those in the control group, in addition, the male students got better performance than the female students. A two-way MANOVA was conducted to compare effects of group and gender on the forehand and backhand skills acquisition (Table 1). The analysis results showed that no significant interactive effects between group and gender factors in forehand skill ($F(1,46) = .75$, $p = .393$), besides, neither main effect of the group factor

(F (1,46) = 1.71, p =.197) nor the gender factor (F (1,46) = 1.14, p =.291) were observed. It indicated that the acquisition of forehand skill will not be affected by different gender, and students in experimental group performed as well as those in the control group.

However, for backhand skill acquisition, the interaction of group factor and gender factor was significant (F (1,46) = 6.33, p <.05). To further clarify effects of gender and group in backhand skill, a simple main effects analysis was conducted to investigate the effect of gender between groups. The results showed that the effect of gender on the backhand skill is significant in control group (F (1,23) = 13.58, p <.05), however, is non-significant (F (1,23) = .06, p =.938) in the experimental group. It indicated that the gender difference still exists (Male: M=17.06; Female: M=6.26) while learning backhand skills by the traditional instruction approach, however, through reflective activities with watching shot-data in their videos might help to reduce the gap between genders (Male: M=17.70; Female: M=17.47). Another simple main effect analysis was used to clarify the effect of group factor between genders. The results declared that the effect of instructional approach on the backhand skill was significant for female students (F (1,20) = 11.53, p <.05), but is non-significant for male students (F (1,26) = .06, p =.810). It shows that female students benefit more from our instructional approach than the traditional methods (Experimental: M= 17.47; Control: M=6.26), but male students are good at both methods (Experimental: M= 17.70; Control: M=17.06).

Table 1.The MANOVA Results on Students' Performance

	Source	**SS**	**df**	**MS**	**F**	***p***
Forehand	Group	96.79	1	96.79	1.71	.197
	Gender	64.58	1	64.58	1.14	.291
	Interaction	42.14	1	42.14	.75	.393
	Error	2601.61	46	56.56		
Backhand	Group	383.04	1	383.04	7.98	.007*
	Gender	331.63	1	331.63	6.91	.012*
	Interaction	304.09	1	304.09	6.33	.015*
	Error	2208.21	46	48.00		
Total	Group	894.38	1	894.38	6.35	.015*
	Gender	715.20	1	715.20	5.08	.029*
	Interaction	549.11	1	549.11	3.90	.054
	Error	6481.87	46	140.91		

*p < .05

3.2 How Females and Males Performed Differently When Making Shots?

In order to identify the differences between genders when making shots, we analyzed students' forms and shot-data in the end-of-semester ITN test. All students' shot data and videos were recorded while attending the test. We randomly selected five males' and five females' videos from each group and analyze their performance in critical tennis techniques. In general, the key movement patterns for tennis beginners includes (1) proper timing for making a shot; (2) control of the wrist angle and racket angle while hitting the ball; (3) accurate swing trajectory; (4) maintaining balance and center of gravity when making a shot. In addition to this, the ability to (5) predicts the flight trajectory of an approaching ball, and (6) hit the "sweet spot" are also critical technical skills in tennis learning. The videos were analyzed with an experienced tennis teacher (the 2nd author) based on the six key techniques mentioned above.

By analyzing the videos from both groups, we found that male students performed better on the timing for making a shot compared to female students. The reason for this difference may be due to male students could predict the flight trajectory of an approaching ball more correctly, in addition, their movement is faster than female students. These advantages benefit male students to perform a relatively complete swing pattern (Figure 2). However, the misjudgment of flight trajectory usually forced female students changed their forms to fit the ball's position and affect their swing patterns as well as the timing of hitting (Figure 3). In addition, the major differences between male and female students on shot-data scores are the swing speed as well as the spin level. Such a difference could be attributed to the physical limitations that males usually have greater physical power than females.

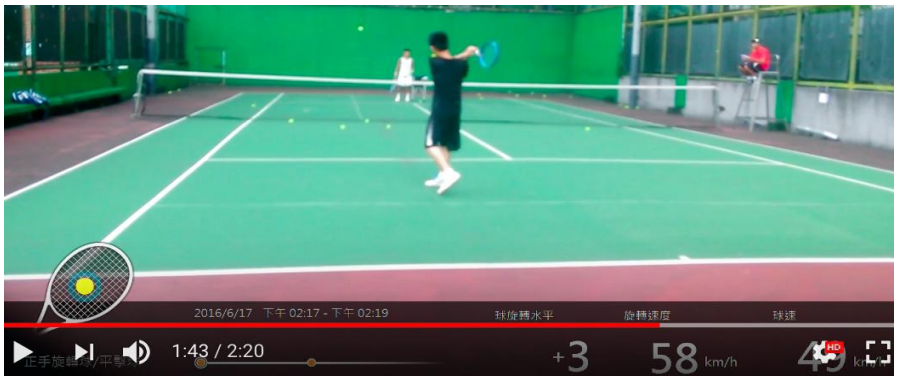

Figure 2. A Student Hit the Ball with a Relatively Complete Swing Pattern

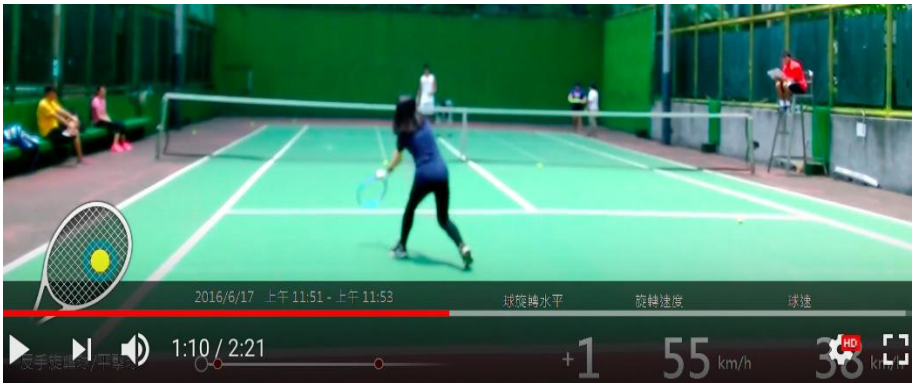

Figure 3. A Student Did Not Hit a Ball with The Proper Timing

The videos also showed the skill of maintaining balance and shifting the center of gravity while hitting were the most common problems in both male and female students. However, the issues like the timing of hitting, angle control of the wrist and racket, and the swing pattern seem more serious in the control group. Some students in control group only swing the racquet to touch the ball but ignored the importance of swing pattern and shifting the center of gravity (Figure 4).These incorrect forms also lead to a low score of shot-data, such as a negative value of ball spin level and the bad impact spot.

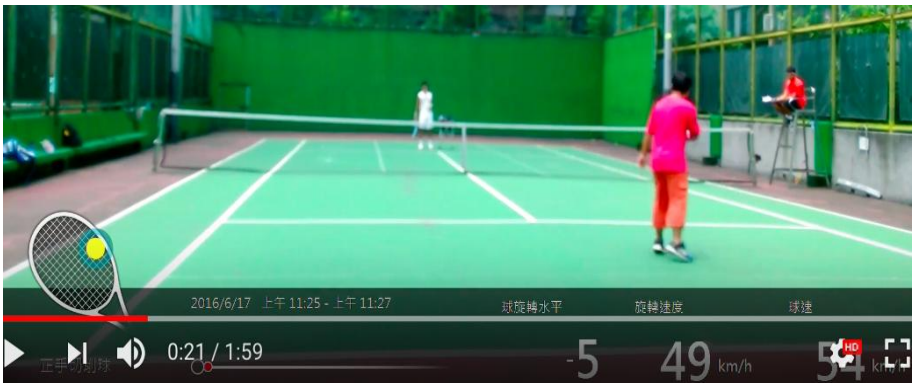

Figure 4. A Student Hit a Ball Without a Complete Swing Pattern

Overall, those students in experimental group performed a relatively smooth swing pattern and had better shot-data scores, such as higher swing speed and spin level, compared to those in control group. We think the positive effect on the form and shot-data in the experimental group might be attributed to the reflection activities engaged them to view their own videos and observed the flaws. By examining their videos with the instructor's demonstrations help them to correct the forms more effectively. Additionally, when they feel confident in their action, they are able to use power and got higher scores on swing speed or spin level.

3.3 How Females and Males Reflected Differently on Their Skills?

Six weeks of reflection content related to the forehand and backhand skills were collected in experimental group. With a total of 135 posts were analyzed by an experienced tennis teacher based on critical tennis techniques. We count the number of times that each key technique was mentioned in the posts by the different gender. The percentages of each technique mentioned by different gender are presented in Table 2.

According to the results, we can find each technique had a similar distribution between males and females. Therefore, male students are more likely to refer to the other aspect (11.96%), such as their expectations and emotions, compared to female students (2.56%). This result might due to the difference of psychological tendency between males and females. Males usually showed greater interest in sport than females, thus they will express more personal feelings while reflecting.

In addition, male students pay more attention to the swing path problems (27.17%); but for female students, the firming wrist and racquet angle problems (26.28%), as well as the hitting timing (25.64%) were their major flaws (26.28%). These results echo the problems found in video analysis. Male students performed better on the timing for making a shot, but they usually ignored the importance of swing pattern, and the misjudgment of flight trajectory caused female students missed the timing for hitting and forced to change their forms. It revealed that both male and female students could correctly reflect according to their flaws.

Both genders hardly mentioned the flight trajectory problem (Male: 0%; Female: 0.64%) and whether they hitting the sweet spot (Male: 2.17%; Female: 0%). Self-reflection can help students to become more aware of their strengths and weakness, and we think the reflective activities could facilitate tennis beginners to correct their form regardless of the gender. However, despite the sensor provided a precise impact spot data for each shot in videos, students rarely mentioned it in their reflection. We suggest further study should provide students a framework for reflection and stress how to interpret the shot-data in their reflective activities

Table 2. Percentages of Students' Reflection on Key Tennis Technique

Reflection types	Gender	
	Male (N=10)	Female (N=15)
1. Identifying the flight trajectory of an approaching ball	0.00%	0.64%
2. Proper timing for making a shot	20.65%	25.64%
3. Control of the angle of the wrist and racket when hitting the ball	20.65%	26.28%
4. Whether hitting the ball on the sweet spot	2.17%	0.00%
5. Whether the swing path is proper	27.17%	22.44%
6. Maintaining balance and shifting the center of gravity of body	17.39%	22.44%
7. Others	11.96%	2.56%

4. CONCLUSION

This study aims to investigate the effect and gender difference through the use of sensor and video data as well as the reflective activities in a beginner tennis class. The results of this study showed that the learning outcome of forehand skill will not be affected by gender or group factor. However, for backhand skill acquisition, using our instructional approach could help female beginners learned better compared to those using the traditional approach, besides, could also reduce the gender difference in beginners. In addition to this, by analyzing the videos, we found male students performed better on the timing for making a shot compared to female students. The major differences between genders on shot-data scores are the swing speed as well as the spin level. Such a difference could be attributed to the physical factors that males usually have greater physical power and faster movement speed than females, these advantages help them to move to the position according to the flight trajectory and performed a relatively complete swing pattern. Overall, those students in experimental group performed a relatively smooth swing pattern and had better shot-data scores

compared to those in control groups. It is obvious that to incorporate the sensor data along with designed reflective activities could help both male and female beginners had better learning performance, especially while learning the more difficult skills, such as backhand groundstrokes. Finally, both male and female students had mentioned the critical techniques in their reflections with a similar distribution, besides, male students are more likely to refer to their expectations and emotions but the female students almost not. Male students pay more attention to the swing path problems, and female students thought the firming wrist and racquet angle problems, as well as the hitting timing, were their major flaws. These results echo the problems found in video analysis and indicated that students are able to reflect according to their flaws. However, even the sensor provided the precise shot-data and impact spot information, students were usually ignored the techniques about identifying the flight trajectory as well as whether hitting the sweet spot.

This study showed that sensor could serve as a useful learning tool as well as an objective evaluating source for teaching tennis beginners. Proper use of the sensor data could enhance the learning performance and reduce the gender difference in sports learning. Future studies should use the sensors to collect data from a large sample of tennis beginning players so that the differences between genders could be thoroughly examined and analyzed. In addition, how to improve the instructional approach while using sensors in class to better fit both male and female students' needs is another critical issue in this field.

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