Journal of Physical Education and Sport ® (JPES), 18(1), Art 34, pp. 255 - 261, 2018
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Embedding tennis-specific teaching videos into long-term educational concepts to improve movement learning and technique performances

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Published online: March 30, 2018
(Accepted for publication February 26, 2018
DOI:10.7752/jpes.2018.01034

Abstract:
Problem Statement: Teaching videos are well-accepted to benefit sport-specific movement learning and technique performances; however, embedded into a long-term educational concept (i.e. university class setting) this remains to be elucidated. Approach: In a pre-post design, 120 students participated to perform a tennis-specific task, comprising technique assessments (TA) of six coach-evaluated technique attributes (TEA; i.e. correct grip, forward-upward swing, racket acceleration, adapted lateral distance to the ball, vertical racket face, stable wrist) as well as a target zone test (TZT) to assess stroke accuracy. Participants were randomly assigned into a study group (SG; n = 89), exposed to teaching videos in support of movement technique learnings, and into a control group (CG; n = 31) without accessibility of the teaching videos. Purpose: This study aimed to investigate the impact of modern teaching videos (e.g. including slow-motion or freeze-frame features and additional verbal instructions) on learning the tennis forehand and backhand techniques. Results: The backhand technique, improved in SG ($p < .05$) compared to CG, most pronounced in the TEAs 'lateral distance' and 'stable wrist'. Although the accuracy of the strokes revealed no differences between the two groups, TZT and TA scores for both strokes were positively correlated. Additionally, 88.8% of the participants self-evaluated the use of teaching videos in class as positive or absolutely positive. Conclusion: This study supports the use of teaching videos within university tennis classes to benefit a development of TEAs in the forehand and backhand. However, distinct improvements seem to require modern features to emphasize a TEA in the teaching video (i.e. freeze-frames or additional verbal instructions). With respect to different learning conditions, a wider movement technique test battery may serve future approaches to additionally investigate different age groups (e.g. early learners in schools vs. senior learners in clubs).
Key words: movement learning, learning environment, physical education, didactics, digital learning.

Introduction

Processes of learning an unfamiliar sport-specific movement technique may benefit from assistive biomechanical devices as well as from providing different verbal and visual instructions (Hottenrott und Neumann, 2014). In this context, teaching videos have been suggested to better illustrate a complex learning content that may be more difficult to describe when using verbal instructions only (Niegemann et al., 2004). Teaching videos have been used in learning environments since the 1960s (Zawacki-Richter, 2011) and their regular use is well established until today (Antretter, et al., 2014). While learning environments (e.g. at a university) aim to develop and follow state-of-the-art educational concepts, in its didactics and methods, more and more new media contents are integrated, not least to serve the upcoming student generation's interests (Falke, 2009). With this, recent research reports 63% of the students and 56% of the teachers to use teaching videos (Börner et al., 2016). Overall Falke (2009) considers teaching videos as high potential when used in learning environments, including schools and universities.

According to a high information density, teaching videos particularly serve the clarity and time necessary for beneficial instructions in favour of a successful movement learning process (Niegemann et al., 2004; Hubwieser, 2007). With this, teaching videos allow for elucidating movements or partial movement components, which may be difficult to identify in the first place (Schön & Ebner, 2013). Particularly in the beginning of a movement learning process the learner requires a motion imagery of the movement technique preceding its performance (Hotz, 2002). As the initial orientation for each learner, visualising a movement technique may be considered as crucial (i.e. outer picture; Deutscher Tennis Bund, 2017b). Subsequently, the dynamic-kinaesthetic motion experience may be added (i.e. inner picture; Hotz, 2002). Gabler and Schrade (1979) report the following of an outer-inner-picture method to be useful and practical, particularly in a tennis context.

The groundstrokes forehand and backhand are usually the first strokes tennis novices learn because these strokes enable them to play with each other. In comparison, the forehand is considered to be easier to learn

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due to a more familiar and natural movement while the backhand - most of the times - is considered to be a new and unfamiliar movement for the students (Schönborn 2006). In order to analyse the movement technique of tennis groundstrokes, the 'functional movement analysis' (FMA) is the common method (Deutscher Tennis Bund, 2017). The FMA subdivides the movement technique into a 'main action' and several 'auxiliary actions' in which the main action comprises parts of the movement that are non-replaceable in order to hit a successful stroke. Within this main action several technique attributes (TEA) can be defined as crucial. In order to bring particular attention to predefined TEA, today's modern teaching videos provide additional features such as slow motion or even frame-by-frame visualisation that allow demonstrating a motion or a movement technique step-by-step and, thus, support and optimize a learning process (Dannemann, 1980; Niegemann, et al., 2004) as well as add to a more interesting, motivating, informative and eventually effective teaching-learning-environment (Haimerl, 2001; Gröben & Prohl, 2002). Moreover, and with respect to increasing and today almost unlimited accessibility of new media contents (i.e. using mobile devices such as smartphones and tablets), teaching videos are available as often as necessary (Haimerl, 2001; Meinhard, Clames, & Koch, 2014).

Previous research suggest positive effects of teaching videos on learning processes, i.e. in the fields of gymnastics, track and field or high jump (Kirsch, 1975). Emmen et.al (1985) examined the impact of video-instructions as well as video-feedback on the technique learning process in tennis, i.e. on the serve. Participants improved their serve technique as well as serve accuracy that, in contrast to Kirsch (1975), was not modulated by using teaching videos. Although the use of teaching videos may be considered as common practice, a long-term impact of learners (i.e. students) being exposed to modern teaching videos that are concomitantly and repeatedly embedded in a movement learning process (i.e. university tennis courses) remains to be elucidated, in particularly with respect to the effectiveness of modern teaching videos on the learning process of a sport-specific movement technique.

However, today's generation of movement technique learning videos offers more detailed perspectives resulting from technical developments in the past decades that eventually may cause a different effectiveness in students learning the respective movement. Therefore, the present study's leading research questions are if and to what extend the use of teaching videos support a technique learning in tennis, particularly in a university class setting. It was hypothesized that (1) being regularly exposed to teaching videos results in greater learning success of the tennis forehand and backhand movement technique, particularly (2) increasing the accuracy of the strokes.

Materials & Methods

Participants

Recruited from basic tennis courses (nine in total) at the German Sport University Cologne, 120 students (75 males, 45 females) volunteered to participate in this study; regularly, 20 students are enrolled in one course. Matching male/female ratios, courses were randomly assigned with six courses (n=89 students) serving as a study group (SG) and three courses (n=31 students) serving as a control group (CG). All participants passed medical examination prior to studying sport and exercise science at the German Sport University Cologne and were considered as recreationally fit at the time of the study.

Procedure

During the summer semester 2017, 14 or, depending on a public holiday, 13 weeks of basic tennis courses with one 90 minute-lesson were hold each week. In a pre-post-design (eleven weeks between tests) to assess technique performances (i.e. tennis-specific performance task), teaching videos served as intervention. SG participants were regularly exposed to teaching videos regarding the forehand and backhand technique throughout the whole semester including on-demand accessibility via an e-learning platform (i.e. moodle) to allow for and enhance self-studying. CG participants watched the teaching videos once prior to pre-testing; however, teaching videos were not used in the CG tennis courses throughout the semester lessons. All students could attend an additional tennis tutorial as an open-access-option during the summer semester. Subsequent to analysing the post-test questionnaire, 14 CG participants had to be excluded from further analyses due to unintended access to the teaching videos for self-studying. To test for tennis-specific technique performances, TEA were predefined: 'correct grip/hand position', 'forward-upward swing towards impact', 'racket acceleration towards impact', 'adapted lateral distance to the ball during impact' (see Figure II), 'vertical racket face during impact' (see Figure II) as well as 'stable wrist during impact' (Deutscher Tennis Bund, 2017c; Schönborn, 2008).

Teaching videos

Professionally developed teaching videos (mospac GmbH, Zurich, SUI) used in this study focussed on the forehand and backhand strokes (one teaching video each). The forehand and backhand strokes were shown in consecutive methodological structures (i.e. from the ready position to the end of each motion) and didactically conceptualized (e.g. using different perspectives and angles, see Figure II). Each teaching video consists of the following sequences:

1. Stroke technique in real time (lateral perspective)
2. Stroke technique in slow motion with additional (written) instructions as well as 'freeze' frames at crucial points of the movement technique (see Figure I)
3. Stroke technique shown from different angles and perspectives (i.e. lateral, frontal, rear) again with 'freeze' frames

Short and precise instructions to execute each stroke technique are displayed (See Figure I). Teaching videos were presented without any sound. Presenting the teaching video for the forehand stroke took 1:46 minutes, the teaching video for the backhand stroke took 2:25 minutes.

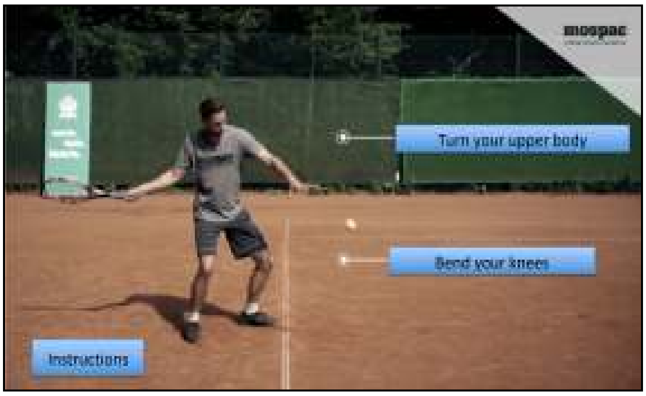

Fig. 1. Screenshot from the forehand teaching video. Lateral view prior to impact

Fig. 2. Screenshot from the forehand teaching video. Lateral and front view at impact.

Pre-test

Prior to the experiment and subsequent to filling in a short questionnaire regarding their level of experience in tennis, each participant was exposed to both teaching videos, first the forehand and second the backhand stroke technique. Immediately after this, each participant performed a standardised tennis-specific performance task, which was designed in accordance to the 'German Tennis Badge' (Deutscher Tennis Bund, 2015). Positioned behind the baseline, participants were instructed to hit 10 forehand and 10 backhand strokes (i.e. each task consisting of five strokes cross-court followed by five strokes down the line). Balls were fed out of a basket by an experienced coach. Subsequent to each hit, the first and second bounce of each ball was recorded, resulting in six different possible outcomes and eventually points collected. In this context, 'longer' strokes with their first bounce behind the service line were rated as better quality than those with their first bounce in front of the service line (Schönborn, 2006).

1. Net or out = 0 points
2. In but in the wrong part of the court (e.g. down the line instead of cross court) = 1 point
3. 1st bounce in front of service line and second bounce inside of the court = 2 points
4. 1st bounce in front of service line and second bounce behind the baseline = 3 points
5. 1st bounce in between service line and baseline and 2nd inside of the court = 4 points
6. 1st bounce in between service line and baseline and 2nd behind service line = 5 points

Scoring is based on the 'Target Zone Test' (TZT) with a highest possible TZT score of 100 points; 50 points resulting from successful forehand and 50 points from successful backhand strokes.

Additionally, coaches evaluated technique performances (i.e. 'technique assessment', TA), evaluating six different TEA for each forehand and the backhand strokes respectively separately. The TEA was assessed in five stages, ranging from ‚not noticeable at all = 1', ‚not noticeable = 2', ‚unstable = 3', ‚noticeable in rough form = 4', to ,noticeable in fine form = 5'. Regarding the TA the highest possible score was 60 points, 30 points each.

Post-test

Prior to the post-test (i.e. eleven weeks later), SG participants were exposed to both teaching videos, whereas CG had no access prior post-test. The tennis-specific performance task as well as its evaluation was identical to the pre-test. After having completed tennis-specific performance task, each participant (SG and CG) filled in a questionnaire regarding their additional tennis activity, possible additional use of the teaching videos outside the tennis lessons (i.e. self-studying opportunities for SG participants) as well as their evaluation of the helpfulness and comprehensibility of the teaching videos (Likert scale rating from 1 to 5, 5 being the best score).

Data collection and statistical analysis

Collected data was edited using Microsoft Excel 2000 and statistical analysis was computed using SPSS. For descriptive analytics, means (M), standard deviations (SD), medians (Mdn) and relative frequencies were computed. Mann-Whitney-U test was carried out to compare initial differences between groups (i.e. SG, CG) and *t*-test to examine mean differences between groups; if there were violations of variances, the Welch-test for independent samples was carried out (see Rasch, Kubinger & Moder, 2011). The *t*-Test for associated samples was used to examine the participants' pre-to-post changes in the tennis-specific performance task.
Bivariate correlation analyses were carried out to test for correlations between the TZT and the TA score. To determine the extent of the correlation the classification of Cohen (1992) was used: r = .10 weak effect, r = .30 medium effect, r = .50 strong effect. The level of significance was set for $p \leq .05$. Data in the text are presented as mean, median and SD.

Results

Tennis-specific performance task: Analyses showed improvements for all students over all measured tennis-specific performance markers (each $p<.05$).

In both groups, the TZT scores in the pre- and post-test of the forehand (pre-test: $M = 23.36 \pm 11.88$; post-test*:* $M = 27.36 \pm 10.81$) increased (pre-test: $t_{(234.43)}=2.00$, p<.05; post-test: t(238) = 2.790, $p<.01$) compared to backhand strokes (pre-test: $M = 20.46 \pm 10.50$; post-test: $M = 23.89 \pm 10.5$); however, SG revealed no differences compared to CG, neither for the forehand (p=.31) nor for backhand strokes (p=.31). Further, combined total scores of the forehand and backhand strokes revealed no differences, neither between SG and CG ($t(118)=.304$, $p=.762$) nor from pre- to post-testing ($t(118) = 1.143$, $p=.255$).

In the pre-test, TA results of both forehand ($t_{(118)}=1.23$, p=.221) and backhand strokes ($t_{(62.38)} = 1.25$, p=.217) showed no differences between SG and CG; however, SG revealed increased improvement of the backhand strokes ($t(118) = -2.001$, $p<.05$) compared to the CG from pre- to post-testing as well as a tendency to increase the improvement of the forehand strokes ($t(118) = -1.922$, $p=.057$) compared to the CG from pre- to post-testing. Also, there was a tendency that SG improved their overall technique compared to CG (p=.057) from pre- to post-testing. Irrespective of group, TA attribute 'swing performance' of the backhand improved compared to the forehand strokes from pre- to post-testing (p<.05), whereas TA attribute 'stable wrist' of the forehand improved compared to the backhand strokes (p<.05) from pre- to post-testing. From pre- to post-testing, TA attributes 'lateral distance' (p<.05) as well as 'stable wrist' (p<.05) improved in SG compared to CG, and TA attribute 'racket face' showed a tendency to improve in SG compared to CG (p=.79).

Questionnaire: Tennis experience levels according to the amount of hours playing tennis (SG: M=3.59 ± 2.08; CG: M=3.42 ± 1.93; z=-.179, p=.858) as well as the attended tennis lessons (SG: M=3.00 ± 2.24; CG: 2.62 ± 2.04 SD; z=.512, p=.609) were reported as similar between SG and CG prior to the study.

An additional tennis tutorial class was more attended by CG compared to SG ($z = -2.368$, $p<.05$) while there was no difference in the amount of hours the two groups played tennis outside of the classes ($z = -.295$, $p=.768$). About 60% of SG watched the teaching videos 1-2 times additionally to the classes; about 20-25% didn't watch the teaching videos outside of the classes. 46.1% watched the backhand video more often while 23.6% watched the forehand video more often. 88.8% of the students evaluated the use of teaching videos in the classes as positive or absolutely positive.

All students confirmed the teaching videos as easy to understand and agreed that teaching videos helped to improve their movement technique imagination (Forehand $M = 4.04$, Backhand: $M = 4.05$), irrespective of different levels of previous tennis experience.

Correlations: Correlations were shown between the TZT score and the TA score of the forehand (pre-test: $r = .667$, $p<.001$, $n = 120$; post-test: $r = .666$, $p<.001$, $n = 120$) and the backhand strokes (pre-test: $r = .574$, $p<.001$, $n = 120$; post-test: $r = .568$, $p<.001$, $n = 120$) in pre- and post-testing.

Discussion

This study aimed to investigate the impact of the use of teaching videos in university tennis classes regarding the development of overall tennis-specific movement technique performance in forehand and backhand strokes, particularly addressing the accuracy of the strokes as well as standardized coach-evaluated technique attributes.

The present study's pre-test findings revealed higher TZT scores for the forehand compared to backhand strokes in both groups, which confirms previous reports stating that at the beginning the forehand is a more familiar and natural movement as well as easier to learn than the backhand (Schönborn, 2006). Further and according to 11 weeks of regularly conducted 90 minutes tennis classes, post-testing revealed an overall positive development over all assessed tennis-specific performance markers (i.e. movement technique attributes) in both groups as expected (International Tennis Federation, 2018). However, there were no differences between the groups (i.e. SG, CG) in the TZT scores, which may underline previous research by Emmen et al. (1985) suggesting that students improve the accuracy of their strokes and show movement technique improvements irrespective of the use of teaching videos. This, however, is in contrast to earlier reports by Kirsch (1975).

With respect to a more detailed approach using TA, the present study's findings show movement technique improvements in favour of the SG for the backhand as well as, at least by trend, for the forehand and overall scores, which supports previous evidence (Kirsch, 1975). It seems reasonable that greater differences for the backhand strokes may result from the students' more familiar forehand movement technique supported by the pre-test findings compared to the students' relatively new backhand movement technique. It seems that watching a teaching video while learning a new movement technique (i.e. backhand) is of greater support than for learning or aiming to improve an already more familiar and/or more developed movement technique (i.e. forehand). Hotz (2002) supports this line of thought with respect to the importance of good initial motion imagery at the beginning of the learning process.

Without distinguishing between forehand and backhand, SG improved TA's 'lateral distance' and 'stable wrist at impact' as well as, at least by trend, 'racket face'. Thus, there is reason to believe that watching teaching videos within a learning process supports students in finding the correct lateral distance to the tennis ball, in having a more stable wrist at impact as well as in setting a vertical racket face at impact. In the present study's teaching videos, these TA are clearly seen and may easily be rehearsed by using the freeze frames underlined by the instructions provided in the teaching videos, which is in line with previous research addressing advantages and benefits of teaching videos, in particular features on 'slow-motion' and 'freeze frame' (Dannemann, 1980; Niegemann et al., 2004; Hottenrott and Neumann, 2014; Hubwieser, 2007; Schön and Ebner, 2013).

Irrespective of having used the teaching videos, both groups improved their backhand compared to their forehand strokes, as shown in the present study's assessed TA 'swing' and reversed in TA 'a stable wrist at impact'. At first, this may suggest that TA 'swing' and 'a stable wrist at impact' may be considered as crucial TA when distinguishing between backhand and forehand strokes in a learning process. The greater improvement of the wrist stability of the forehands may be explained by the fact that all backhand strokes were performed double-handed and, thus, may be considered to have a greater wrist stability in the first place. It is well accepted that a double-handed backhand serves greater 'wrist stability' from the beginning because of the help of the second hand. Therefore, less greater improvements in the present study's TA 'stable wrist at impact' for the backhand strokes seem reasonable. Regarding TA 'swing' the findings can also be explained by the reason already mentioned above. Since the forehand is usually a more familiar movement than the backhand the students dared to use a full swing from the beginning on whilst they first had to learn to swing their backhand. Additionally since there is only one hand on the racket when playing the forehand it is easier to really swing the racket than with two hands when playing a backhand.

Although the present study's TZT scores revealed no differences according to the use of teaching videos, there were strong positive correlations between TZT and TA scores, supporting a learning process with respect to coach-evaluated tennis-specific movement technique performances. With this, coaches' evaluations may serve the prediction of noticeable changes for the forehand and backhand stroke performances in both SG and CG.

Last but not least, while the above discussed results in relation to the large number of SG students having used and considered the teaching videos as positive (i.e. 88.8%) is in line with recent research suggesting a high potential for teaching videos in a university setting (Falke, 2009), it is partly contradicted by the relatively low number of SG students having used the teaching videos for self-studying and the idea of teaching videos to fit in younger adults learning methods (Meinhard, Clames, & Koch, 2014). However, it has to be taken in account that the post-test was assessed three weeks prior to the student's final exam in class. It may be assumed that using the teaching video for self-studying would have increased closer to the final exams, as this tends to increase practicing hours in students.

Conclusions

This study shows that the use of tennis-specific teaching videos within university classes has a positive impact on the learning process of tennis-specific movement technique performance attributes (i.e. TA), in particular the forehand and backhand strokes. Improvements of TA that are emphasized in the teaching videos are most pronounced when applying freeze frames and additional instructions to support self-studying. Although there was no improvement in the strokes' accuracy, strong correlations between the strokes' accuracy and coach-evaluated movement technique performances serves a reasonable impact of teaching video use on improving strokes' accuracy.

Despite difficult practicability, future research on the impact of sport-specific teaching videos, also addressing additional learning environments such as physical education in schools, may consider an extension of measurements (e.g. pre-test, weekly assessments during class over the entire educational period, post-test, retention-test).

Conflicts of interest

All authors declare no actual or potential conflict of interest, including any financial, personal or other relationships with other people or organisations that could inappropriately influence, or be perceived to influence, the publication of this work.

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