THE EFFECTS OF VIDEO MODELING AND SIMULATION ON TEACHING / LEARNING BASIC VAULTING JUMP ON THE VAULT TABLE

Asma Amri-Dardari[1], Bessem Mkaouer[1], Sarra H. Nassib[1,2], Samiha Amara[1], Rachid Amri[3], Fatma Zohra Ben Salah[4]

[1] Higher Institute of Sport and Physical Education of Ksar Saïd, Manouba University, Tunisia
[2] Tunisian Research Laboratory "Sport Performance Optimization" of the National Centre of Medicine and Science in Sport, Tunis, Tunisia
[3] Faulty of Arts and Humanities. University of Kairouan, Kairouan, Tunisia
[4] Faculty of Medicine of Tunis, University El Manar, Tunis, Tunisia

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Abstract
The purpose of this study was to compare the effects of different teaching / learning strategies (i.e., verbal feedback, video feedback with modeling, and video feedback with simulation) on performing basic vaulting skills on the vault table. Three male groups of undergraduate students in physical education (i.e., 135 students, divided into 3 groups of 45 subjects) took part in this study. The groups (i.e., traditional, modeling and simulation groups) were divided on equal terms; students are not gymnasts, have the same level and taught by the same teacher. All participants were pretested to determine initial skill level (i.e., direct piked vault). This study covers 24 stoop direct vault sessions, 21 learning and three evaluations spread over 12 weeks (i.e., 2 sessions per week). A video motion analysis (i.e., using Kinovea software) was used to evaluate direct piked vault skills/performance. The results indicate a better improvement of performance in the modeling group compared to the simulation and traditional groups (vault score, 11.80±1.22 pts, 10.85±1.50 pts and 9.01±1.30 pts, respectively with p<0.01). In addition, the analysis of delta-percentage revealed a considerable enhancements of technical performance in the modeling group (46.93%) compared to simulation (27.62%) and traditional (21.64%) groups. In conclusion, video feedback with model's superposition had led to better learning improvements in vault jump compared with simulation and verbal feedback methods. The video return with the overlay of the model enabled a lot of basic skills learning improvement at the vault table.

Keywords: *video feedback, modeling, simulation, learning, vault table, physical education.*

INTRODUCTION

Following the evolution of new information and communication technologies (ICT), the use of video and appropriate software's has been evaluated in many research areas over the last decades (Casey & Jones, 2011). Also, the video modeling and simulations of the human body has been the subject of many sports studies (Yang, 2015). In fact, the use of technology in the gymnastics learning allows the student to have additional resources to mobilize, learn, and reflect on their learning, production, or even communication. Using video systems in the gymnastics sector, reflects on two distinct approaches to performance: visualization of performance (i.e., qualitative approach) and performance analysis (i.e., quantitative approach) (Mkaouer, Chaabene, Amara, Nassib, Negra, & Jemni, 2018; Potdevin, Vors, Huchez, Lamour, Davids, & Schnitzler, 2018). While totally different, these two procedures for using video work together for a common goal which is improving performance. The use of the various video modes (i.e., modeling and simulation) provides both learners and teachers with an important background information.

In gymnastics, video recordings are mostly used for technical analysis and measurement of kinematic variables (Mkaouer et al., 2018). However, works on motor education have recognized another potential use of this technique, which is modeling and simulation.

The literature exposes several forms of video feedback that inspire the modeling method (Harvey & Gittins, 2014; Potdevin et al., 2018). More recently, three modeling forms have been presented: (1) self-modeling, is a procedure of observational learning with the distinction that the observed and the observer, the object, and the subject, are the same person, (2) expert-modeling, where the observed and the observers are not the same person, and (3) model's superposition (self vs. expert model), were the observer and the observed are superposed in the same video for comparison (Amara, Mkaouer, Nassib, Chaaben, Hachana, & Ben Salah, 2015; Baudry, Leroy, & Chollet, 2006; Boyer, Miltenberger, Batsche, & Fogel, 2009; Le Naour, Ré, & Bresciani, 2019). Likewise, there is a video-simulation, which is a kind of video-modeling, it is a virtualization of the ideal movement (i.e., self-modeling with error correction and technical optimization). Video-simulation, is a virtual reality of learner perfect movement, based on their own abilities (Zhou, 2016).

In the last decades, athletes' knowledge and motor performance are developed with modeling sports skills through simulation and motion analysis software as Human Movement Bulider, Skill Spector and Kinovea (Harvey & Gittins, 2014; Stanescu & Stoicescu, 2012).

The modeling of sports techniques would be a key issue in optimizing performance (Laffay, & Orsay, 2008). Used in combination with video feedback, video modeling shows a significant effect on the behaviour measured in various studies (Boyer et al., 2009; Le Naour, Ré, & Bresciani, 2019; Nielsen, Sigurdsson, & Austin, 2009). This tool also offers an interesting flexibility of use for learning movement: the action can be viewed several times, at different speeds. It can also be stopped on a specific element to be analysed. All these possibilities allow the practitioner to better discern the different phases of the movement and, thus, facilitate its acquisition (Laffay, & Orsay, 2008). Therefore, we can say that the video-modeling would be a very effective teaching tool. It allows both teacher / trainer and taught / athlete to improve their knowledge of body in motion and mental representation during the didactic act (Le Naour et al., 2019). In addition to modeling, there is also a new complex teaching tool, which is video simulation. It is a virtualization of the learner's movement to correct / improve these skills. In the literature, only one study has been carried out in teaching / learning gymnastics skills, more precisely teaching choreography (Zhou, 2016).

Many studies presented a positive effect of video feedback in different physical activities (Clark & Ste-Marie, 2007; Roosink et al., 2015; Weir & Connor, 2009; Veličković, Petkovic, & Petkovic, 2011). Boyer et al. (2009) studied the effectiveness of a video sequence treatment including modeling and feedback on the acquisition of three gymnastic skills in a multiple basis in behavioural design. There was a clear increase in the acquisition of a skill set with the introduction of the video sequence processing. Nielsen et al. (2009) evaluated a procedure in which participants marked the video models and received feedback on the scores. However, only four studies have examined the effectiveness of the combination of video feedback and video modeling by experts and or novices. Baudry et al. (2006) has studied the effect of combined self- and expert-modeling on the gymnast performance of double leg circle on the pommel horse. Amara et al. (2015) has studied the effect of different methods of video feedback on teaching / learning hurdles clearance. Arbabi and Sarabandi (2016) have made known the effect of performance feedback with three different video modeling methods on acquisition and retention of badminton long service. Le Naour et al. (2019) have assessed the effect of 3D feedback and observation (i.e., using model's superposition) for motor learning in teaching gymnastics skills.

However, few researchers have examined the use of video-simulation and feedback for improving the execution of complex athletic skills such as gymnastics routines that require multiple precise body movements and positions. Only Zhou (2016) focused on virtual technology (i.e., simulation), when he studied the effects of automatic choreography software on the gymnastics teaching/learning process. The didactic interest of such study is to determine the extent of the deep learning carried out by physical education students engaged with ICT in the teaching / learning process. Therefore, it is essential for teachers to integrate video teaching / learning activities (i.e., self-modeling, expert-modeling, model-overlay and simulation) into training programs and provide students with specific knowledge from modeling by video feedback and particularly by simulation which provides a link to specific areas of sports training of the human body.

Thus, since the use of simulation in teaching / learning is very rare, the purpose of this study was to compare the effects of different teaching / learning strategies (i.e., verbal feedback, video feedback with modeling, and video feedback with simulation) on performing basic vaulting skills in the vault table. Also, a qualitative and quantitative measure was associated to simplify the complexity of vaulting jump and detect the determinants of performance.

Besides, our hypothesis, based on the previous studies (Baudry, 2003; Boyer et al., 2009; Le Naour et al., 2019; Veličković et al., 2011; Zhou, 2016), was that video-modeling could be better than video-simulation in teaching / learning gymnastics skills for beginner's.

METHODS

Three male groups (age 20.45±1.14 years old, height 1.87±0.32 m, and body mass 80.2±12.3 kg) of undergraduate students in physical education (i.e., 135 students, divided into 3 groups of 45 subjects) and an expert gymnast (i.e., national team male elite gymnast, age 21.54 years, height 1.67 m, and body mass 60.8 kg) took part in this study. The groups (i.e., traditional, modeling and simulation groups) were divided on the basis that students are not gymnasts, have the same level, taught by the same teacher and followed the same training program in the same working conditions (i.e., same hourly, volume and gym). The participants are divided as follows:

- Traditional group (TG) followed a classical learning based on verbal-feedback, technical instructions, safety, explanatory drawings / sketches and partial demonstrations of the teacher.
- Modeling group (MG) followed learning with self-modeling, expert-modeling and model's superposition at each session, in addition to a classical learning based on verbal feedback.

- Simulation group (SG) followed learning with self-modeling and mathematical simulation / virtualisation of their movement, in addition to a classical learning based on verbal feedback.

The expert gymnast participated as a model for the kinematic analysis / modeling of direct piked vault at the vault table.

None of them had received specific intervention before performing the experimental task. It was made clear for them that participation was entirely voluntary and anonymous and that their answers would remain strictly confidential. They were latter informed that the data will only be of used to serve scientific research. The experimental protocol was performed in accordance with the Declaration of Helsinki for Human Experimentation and was approved by the local Ethical Committee.

This study was carried out in two stages (i.e., determination of kinematic model and effects of video-feedback). In the first, a 2D kinematic analysis of direct piked vault was performed (i.e., for the expert gymnast) with two mutually synchronized [Time Code Synchronization, TC-Link] digital cameras [PNJ Cam AEE, Action Cam SD18, 5MP CMOS optical sensor, f / 2.8 lens, 135° wide angle, shutter speed 1 / 4-1 / 10000s, acquisition frequency 120Hz, 720p]. Cameras were placed 5-m away and 1.80 m above the floor with an angle of 60° and 120° for the first and the second camera, respectively. To collect kinematic gymnast vaulting data, twenty markers were attached to the body for digitization. Body markers, using the Hanavan model modified by De Leva (1996), were digitized using the video-based data analysis system SkillSpector® 1.3.2 [Odense SØ – Denmark], (Mkaouer et al., 2018). Similarly, the body segments' COM was computed using the Hanavan model modified by De Leva (1996). In the second, participants, from the three groups (i.e., traditional, modeling and simulation groups), have followed 24 stoop direct vault sessions (i.e., 1h 30min / session), 21 learning and three evaluations spread over 12 weeks (i.e., 2 sessions per week) (Figure 1). Video motion analysis was used through Kinovea software (Jurak, Kiseljak, & Rađenović, 2020; Nassib, Mkaouer, Riahi, Wali, & Nassib, 2017) using an AEE PNJ camera (i.e., Action Cam SD18, 5MP CMOS optical sensor, f / 2.8 lens, 135° wide angle, shutter speed 1 / 4-1 / 10000s, acquisition frequency 120Hz, 720p). The camera was placed at a distance of 5 m of the vault table with a height of 1.80 m. The data simulation, from 2D kinematic analysis (i.e., centre of mass trajectory, take-off angle and speed), was performed using MS Excel and Regressi® Open Source software (Mkaouer, Amara, Tabka, 2012; Trudel, Métioui, & Arbez, 2016) (Figure 2). All participants were pretested to determine initial skill level (i.e., direct piked vault).

This study examined the effect of video modeling (i.e., self-modeling and expert-modeling) and simulation on learning direct piked vault at the vault table by involving the student in problem solving regarding error correcting skills. Mathematical simulation of data, from 2D kinematic analysis, was used to visualize the trajectory of the centre of mass (COM), the angle of attack (i.e., legs / trunk on spring board and arms / trunk on vault table), the position of the trunk, the vertical and horizontal velocity and displacement; all this is done to identify the strengths and weaknesses to improve the direct piked vault (Figure 3).

The experiment was conducted in a gymnastics area of university with the usual conditions of gymnastic sessions of practice. Predictive assessment (i.e., taking performance) took place before the start of the experiment. Arranged situations was organized to learn about this vaulting element (i.e., direct piked vault). During the viewing, the criteria for success in each skill of the vaulting sequence was clearly explained. So, in performing this task, subjects observe partial demonstrations. They visualize key positions of vaulting from postures and rhythmic movements.

The research has begun with four sessions of adaptation with the equipment and the procedure and then a pre-test: it is a predictive evaluation to determine the initial level of gymnastics practice of the students. A formative evaluation has carried out at the fourteenth session and finally the teaching / learning cycle was completed by a summative evaluation test.

Before each experiment, participants were familiarized with the experimental equipment and protocol in order to be able to accurately answer research questions and follow the recommendations given.

During the study, the learning sessions was conducted at the same time of the day for each subject and in their regular class sessions. After the completion of the evaluation sessions, participants were informed about their interventions and received feedback on their performance.

Each vault in gymnastics can be divided into the following seven phases: (a) running, (b) jumping on springboard, (c) springboard support, (d) first flight phase, (e) table support, (f) second flight phase, and (g) landing (Atiković & Smajlović, 2011; Fernandes, Carrara, Serrão, Amadio, & Mochizuki, 2016; Čuk & Karácsony, 2004; Ferkolj, 2010; Prassas, 2002). In the FIG code of points (2017), the evaluation criteria of the vault table are: (a) first flight phase, up to the support with two hands, (b) 2nd flight phase, including the pushing off from the table up to the landing in a standing position, (c) body position in the momentary support on the table, (d) deductions with regard to the deviation from the extended axis of the table, (e) technical execution during the entire vault, and (f) landing. So, the student was scored according to a measure inspired by the FIG code of point (2017) in the principal phases of vault (Figure 4). Table 1 and 2 present the difficulty and execution values of the direct piked vault.

In addition, a scorecard was designed to evaluate vaulting technique (i.e., direct piked vault; figure 4) before and after teaching / learning programs, with a maximum score of 20 points [Technical criteria of assessment (10 pts); Execution Criteria of assessment (10 pts)] for the different phases of vault [Very good (2 pts); good (1.5 pts); medium (1 pts); low (0.5 pts) for each variable] based on kinematic model data (Table 3). Three national judges ensured the assessment of all students during all vaulting evaluations.

Data are reported as mean ± standard deviation and confidence intervals at the 95% level (95% CI). Effect size (*dz*) was calculated using GPOWER software (Bonn FRG, Bonn University, Department of Psychology). The following scale was used to interpret *dz*: < 0.2, trivial; 0.2 – 0.6, small; 0.6 – 1.2, moderate; 1.2 – 2.0, large; and > 2.0, very large (Hopkins, 2002). The normality of distribution, estimated by the Shapiro-Wilk test, was acceptable for all variables. Therefore, a 3 (group: MG, SG, and CG) × 2 (time: pre, post) ANOVA with repeated measures on test was computed. For pairwise comparison, a post hoc / Bonferroni was established. Similarly, the delta-percentage (Δ% = [(G1 - G2) / G2] × 100) was calculated to estimate the percentage change between the three methods. The results were considered significantly different (significant) when the probability is less than or equal to 0.05% ($p \leq 0.05$). The statistical study was performed by SPSS® 20.0 software (SPSS Inc., Chicago, IL, USA).

Table 1
Technical Criteria of Assessment.

Phases*	Direct Piked Vault	
	Requirement	Values (pts)
First flight	Minimum attack at 15 ° from the horizontal surface of the vault table, stretched body	4.00
Second flight	Elevation of the body above the vault table, parabolic trajectory	4.00
Landing	In the minimum landing area after 1m from the vault table	2.00

Note: (*) Maximum 10 points.

Table 2
Execution Criteria of Assessment .

Errors*	Deduction (pts)	Description
Small Error	0.25	Deviation <15 ° from the standard position
Medium Error	0.50	Deviation <30 ° from the standard position
Large Error	1.00	Deviation> 30 ° from standard position
Non recognition / Fall	2.00	Falling at the beginning or end of the movement

Note: (*) Maximum 10 points

Table 3
Kinematical Criteria of Assessment.

Technical Score	Take Off		1st Flight			2nd Flight			Landing	
	Angle (°)	Angle trunk/legs (°)	Angle of attack (°)	Angle arms/trunk (°)	Angle trunk/legs (°)	Vertical displacement (m)	Angle of trunk (°)	Angle trunk/legs (°)	Distance (m)	Stability (m)
Very Good (2 pts)	60°-70°	166°-180°	36°-45°	166°-180°	166°-180°	>0.03m	30°-45°	30°-45°	>2m	0 Step
Good (1.5 pts)	71°-80°	151°-165°	26°-35°	151°-165°	151°-165°	0.02m-0.03m	46°-60°	46°-60°	1.6m-2m	1 Small Step
Medium (1 pts)	81°-90°	121°-150°	16°-25°	121°-150°	121°-150°	0.01m-0.02m	61°-75°	61°-75°	1m-1.5m	1 Big Step
Week (0.5 pts)	> 90°	90°-120°	0°-15°	90°-120°	90°-120°	0.00 m-0.01m	76°-90°	76°-90°	<1m	Several Step

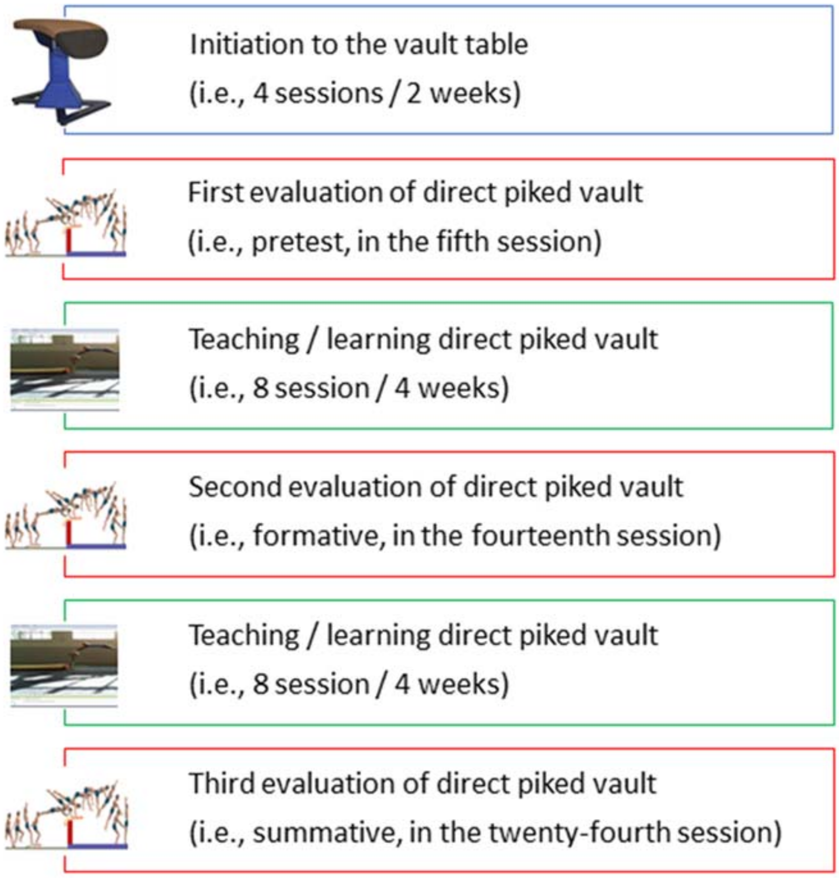

Figure 1. Experimental design of the study.

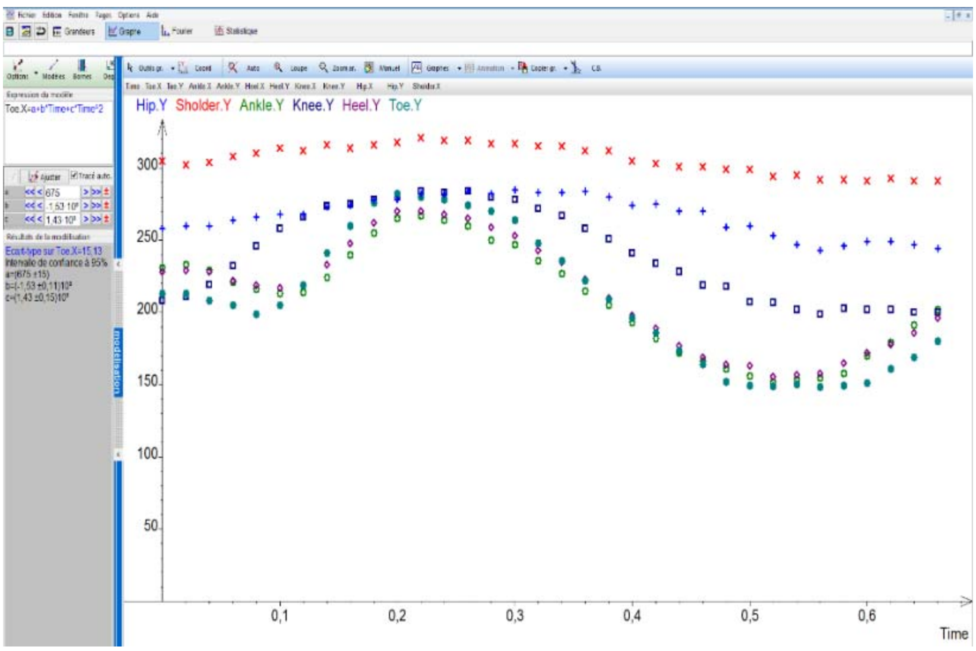

Figure 2. Interface of the Regressi® mathematical simulation software.

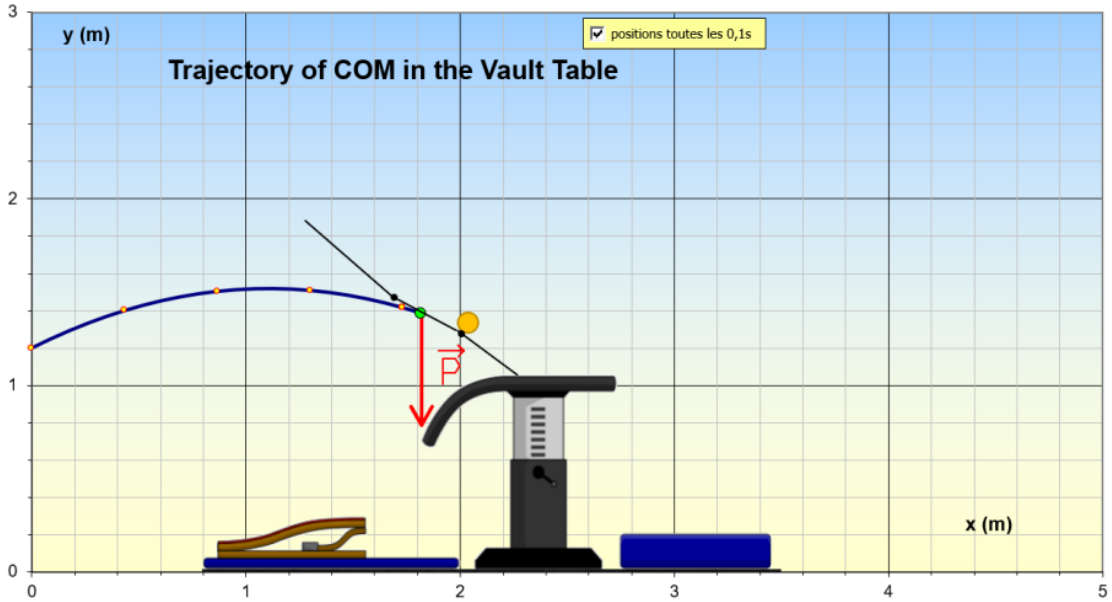

Figure 3. Simulation of the center of mass trajectory in the MS Excel.

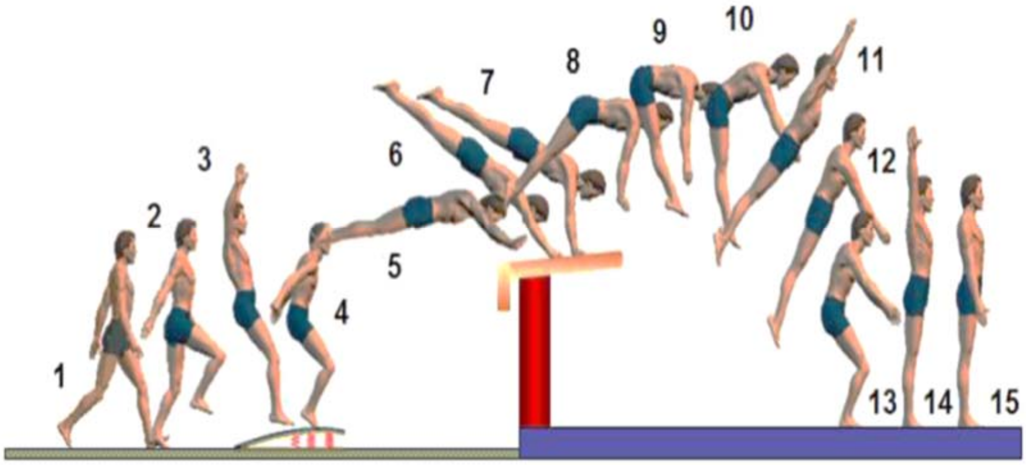

Figure 4. Chronograph of Direct Piked Vault.
Note: Positions [1 - 4] take- off; [5 - 7] 1st flight; [8 - 11] 2nd Flight; [13 - 15] Landing.

RESULTS

Table 4
ANOVA Repeated Measure of Kinematic Variables.

Variables	Traditional Group			Modeling Group			Simulation Group			ANOVA *p* value (*dz*)		
	Pre-test	Post-test	Change (%) (95% CI)	Pre-test	Post-test	Change (%) (95% CI)	Pre-test	Post-test	Change (%) (95% CI)	Time	Group	Group × Time
TO ang SB (°)	72.2±5.3	70.3±4.7	-2.70 (-2.65 to -1.25)	72.8±4.72	65.1±3.1	-10.62 (-9.18 to -6.27)	69.40±5.3	68.20±4.4	-1.76 (-2.59 to 0.14)	0.000 (1.809)	0.012 (0.527)	0.000 (1.484)
Tc/Lg ang TO (°)	128.13±9.77	129.04±8.69	-0.44 (0.88 to 0.01)	124.84±9.58	144.12±8.41	15.82 (15.74 to 23.41)	135.57±9.78	143.20±7.36	5.62 (4.38 to 10.85)	0.000 (1.902)	0.000 (1.216)	0.000 (1.688)
Att ang FF (°)	22.53±4.54	24.57±3.79	9.05 (1.28 to 2.80)	21.26±4.40	30.33±2.65	42.62 (7.54 to 10.59)	22.80±6.49	26.60±4.75	16.67 (1.76 to 5.83)	0.000 (1.972)	0.023 (0.487)	0.000 (1.293)
Am/Tc ang FF (°)	106.20±13.53	115.48±8.08	8.74 (5.87 to 12.70)	105.53±13.49	118.08±9.67	11.89 (7.74 to 17.36)	101.55±13.85	113.51±7.24	11.77 (7.84 to 16.06)	0.000 (1.650)	0.062 (0.413)	0.492 (0.211)
Tc/Lg ang FF (°)	148.48±8.97	151.02±8.51	1.70 (1.34 to 3.17)	148.55±14.24	157.97±10.99	6.34 (3.89 to 14.94)	156.15±17.17	159.02±11.92	1.84 (-1.66 to 7.39)	0.000 (0.717)	0.002 (0.636)	0.033 (0.458)
dy SF (m)	0.172±0.058	0.209±0.044	21.51 (0.026 to 0.049)	0.185±0.051	0.228±0.035	23.24 (0.026 to 0.061)	0.154±0.055	0.182±0.041	18.18 (0.014 to 0.043)	0.000 (1.506)	0.000 (0.762)	0.350 (0.255)
Tc ang SF (°)	108.35±11.10	112.75±7.90	4.06 (2.38 to 6.14)	106.93±10.78	125.86±9.36	17.70 (14.78 to 23.07)	114.11±13.89	120.51±9.60	5.61 (2.35 to 10.45)	0.000 (1.701)	0.001 (0.685)	0.000 (1.102)
Tc/Lg ang SF (°)	64.17±10.04	62.51±10.66	-2.59 (-2.45 to -0.87)	66.44±5.71	51.33±5.94	-22.74 (-17.48 to -12.74)	55.80±12.89	51.66±7.25	-7.40 (-7.91 to -0.35)	0.000 (1.619)	0.000 (0.901)	0.000 (1.359)
Ld dx (m)	1.281±0.201	1.316±0.156	2.73 (0.013 to 0.058)	1.304±0.202	1.582±0.116	21.40 (0.216 to 0.342)	1.268±0.251	1.445±0.189	13.88 (0.092 to 0.261)	0.000 (1.599)	0.000 (0.749)	0.000 (0.974)

Note: (TO ang SB) Take-off angle on spring board; (Tc/Lg ang TO) Trunk/legs angle in take-off; (Att ang FF) Attack angle in first flight; (Am/Tc ang FF) Arm/trunk angle in first flight; (Tc/Lg ang FF) Trunk/legs angle in first flight; (dy SF) Vertical displacement in second flight; (Tc ang SF) Trunk angle in second flight; (Tc/Lg ang SF) Trunk/legs angle in second flight; (dx Ld) Landing Distance.

Table 5
Groups, Bonferroni Post Hoc of Kinematic Variables.

Measures	Groups		Change (%) (95% CI)	Standard Error	Sig.	Effect Size (*dz*)
TO ang SB (°)	Modeling	Simulation	-4.77 (-2.02 to 2.31)	0.893	1.000	0.157
	Modeling	Traditional	-7.91 (-4.43 to -0.10)	0.893	0.037	3.587
	Simulation	Traditional	-2.99 (-4.57 to -.024)	0.893	0.024	3.814
Tc/Lg ang TO (°)	Modeling	Simulation	-4.75 (-8.68 to -0.83)	1.619	0.012	4.153
	Modeling	Traditional	11.28 (2.57 to 10.42)	1.619	0.000	5.676
	Simulation	Traditional	10.52 (7.33 to 15.18)	1.619	0.000	9.830
Att ang FF (°)	Modeling	Simulation	12.31 (-0.84 to 3.04)	0.804	0.521	0.234
	Modeling	Traditional	18.97 (0.29 to 4.19)	0.804	0.018	3.950
	Simulation	Traditional	7.60 (-0.80 to 3.09)	0.804	0.471	0.259
Tc/Lg ang FF (°)	Modeling	Simulation	-4.32 (-9.53 to 0.89)	2.150	0.139	0.375
	Modeling	Traditional	4.40 (-1.70 to 8.72)	2.150	0.314	0.247
	Simulation	Traditional	5.30 (2.62 to 13.04)	2.150	0.001	5.153
dy SF (m)	Modeling	Simulation	20.14 (0.01 to 0.06)	0.009	0.000	6.500
	Modeling	Traditional	8.27 (-0.01 to 0.03)	0.009	0.224	0.258
	Simulation	Traditional	-14.68 (-0.04 to -0.01)	0.009	0.034	3.833
Tc ang SF (°)	Modeling	Simulation	-4.25 (-5.41 to 3.59)	1.859	1.000	0.186
	Modeling	Traditional	10.42 (1.33 to 10.35)	1.859	0.006	4.444
	Simulation	Traditional	6.44 (2.24 to 11.26)	1.859	0.001	5.136
Tc/Lg ang SF (°)	Modeling	Simulation	5.15 (1.04 to 9.26)	1.695	0.009	4.607
	Modeling	Traditional	-21.77 (-8.56 to -0.34)	1.695	0.029	3.981
	Simulation	Traditional	-20.99 (-13.72 to -5.50)	1.695	0.000	8.588
Ld dx (m)	Modeling	Simulation	8.70 (0.01 to 0.16)	0.034	0.034	3.625
	Modeling	Traditional	16.80 (0.06 to 0.22)	0.034	0.000	6.041
	Simulation	Traditional	8.87 (-0.02 to 0.14)	0.034	0.271	0.298

Note:(TO ang SB) Take-off angle on spring board; (Tc/Lg ang TO) Trunk/legs angle in take-off; (Att ang FF) Attack angle in first flight; (Tc/Lg ang FF) Trunk/legs angle in first flight; (dy SF) Vertical displacement in second flight; (Tc ang SF) Trunk angle in second flight; (Tc/Lg ang SF) Trunk/legs angle in second flight; (dx Ld) Landing Distance.

Table 6

Groups × Time, Bonferroni Post Hoc of Kinematic Variables (Differences Pre-test vs Post-test).

Measures	Groups		Change (%) (95% CI)	Standard Error	Sig.	Effect Size (*dz*)
Δ TO ang SB (°)	Modeling	Simulation	6.51 (4.43 to 8.59)	0.858	0.000	1.385
	Modeling	Traditional	5.77 (3.70 to 7.86)	0.858	0.000	1.519
	Simulation	Traditional	-0.73 (-2.81 to 1.35)	0.858	1.000	0.123
Δ Tc/Lg ang TO (°)	Modeling	Simulation	-11.95 (-16.89 to -7.02)	2.034	0.000	0.648
	Modeling	Traditional	-19.57 (-24.51 to -14.65)	2.034	0.000	1.023
	Simulation	Traditional	-7.62 (-12.55 to -2.69)	2.034	0.001	1.008
Δ Att ang FF (°)	Modeling	Simulation	-5.26 (-7.87 to -2.66)	1.076	0.000	0.184
	Modeling	Traditional	-7.02 (-9.63 to -4.41)	1.076	0.000	0.645
	Simulation	Traditional	-1.75 (-4.36 to 0.85)	1.076	0.315	0.154
Δ Tc/Lg ang FF (°)	Modeling	Simulation	-6.55 (-13.67 to 0.56)	2.934	0.081	0.115
	Modeling	Traditional	-6.88 (-14.00 to 0.23)	2.934	0.061	0.138
	Simulation	Traditional	-0.33 (-7.45 to 6.78)	2.934	1.000	0.096
Δ Tc ang SF (°)	Modeling	Simulation	-12.53 (-18.56 to -6.51)	2.486	0.000	0.261
	Modeling	Traditional	-14.53 (-20.56 to -8.51)	2.486	0.000	0.521
	Simulation	Traditional	-2.00 (-8.03 to 4.03)	2.486	1.000	0.087
Δ Tc/Lg ang SF (°)	Modeling	Simulation	10.97 (6.53 to 15.43)	1.834	0.000	0.245
	Modeling	Traditional	13.44 (9.00 to 17.89)	1.834	0.000	0.696
	Simulation	Traditional	2.46 (-1.98 to 6.91)	1.834	0.543	0.107
Δ Ld dx (m)	Modeling	Simulation	-0.10 (-0.21 to 0.01)	0.044	0.062	0.076
	Modeling	Traditional	-0.24 (-0.35 to -0.14)	0.044	0.000	0.752
	Simulation	Traditional	-0.14 (-0.25 to -0.04)	0.044	0.005	0.686

Note: (Δ) delta change; (TO ang SB) Take-off angle on spring board; (Tc/Lg ang TO) Trunk/legs angle in take-off; (Att ang FF) Attack angle in first flight; (Tc/Lg ang FF) Trunk/legs angle in first flight; (Tc ang SF) Trunk angle in second flight; (Tc/Lg ang SF) Trunk/legs angle in second flight; (dx Ld) Landing Distance.

Table 7
ANOVA Repeated Measure of Technical Variables.

Variables	Traditional Group			Modeling Group			Simulation Group			ANOVA *p* value (*dz*)		
	Pre-test	Post-test	Change (%) (95% CI)	Pre-test	Post-test	Change (%) (95% CI)	Pre-test	Post-test	Change (%) (95% CI)	Time	Group	Group × Time
TO ang SB	1.67±0.26	1.77±0.25	5.99 (0.03 to 0.16)	1.63±0.26	2.00±0.01	22.09 (0.28 to 0.44)	1.78±0.24	1.85±0.22	3.78 (0.01 to 0.12)	0.000 (1.585)	0.058 (0.434)	0.000 (1.197)
Tc/Lg ang TO	0.91±0.22	0.93±0.20	2.20 (-0.01 to 0.05)	0.82±0.24	1.12±0.21	36.59 (0.20 to 0.39)	1.01±0.16	1.07±0.18	5.94 (0.01 to 0.12)	0.000 (1.182)	0.005 (0.581)	0.000 (1.111)
Fall TO	0.62±0.29	0.49±0.21	-20.97 (-0.18 to -0.6)	0.61±0.30	0.36±0.12	-40.98 (-0.34 to -0.16)	0.61±0.29	0.37±0.12	-37.70 (-0.32 to -0.15)	0.000 (1.572)	0.178 (0.326)	0.055 (0.429)
Att ang FF	1.00±0.21	1.12±0.24	12.00 (0.05 to 0.18)	0.95±0.20	1.51±0.13	57.89 (0.47 to 0.63)	1.04±0.31	1.30±0.28	24.04 (0.14 to 0.36)	0.000 (2.180)	0.000 (0.745)	0.000 (1.268)
Am/Tc ang FF	0.57±0.18	0.65±0.23	21.28 (0.02 to 0.13)	0.57±0.18	0.73±0.25	26.32 (0.06 to 0.25)	0.53±0.12	0.55±0.15	3.77 (-0.01 to 0.05)	0.000 (0.783)	0.005 (0.581)	0.071 (0.305)
Tc/Lg ang FF	1.16±0.26	1.27±0.32	9.48 (0.04 to 0.17)	1.17±0.30	1.48±0.31	26.50 (0.18 to 0.43)	1.50±0.41	1.54±0.36	2.67 (-0.07 to 0.15)	0.000 (0.905)	0.000 (0.876)	0.001 (0.659)
Fall FF	0.57±0.29	0.50±0.23	-12.28 (-0.12 to -0.23)	0.56±0.29	0.36±0.12	-35.71 (-0.28 to -0.12)	0.54±0.29	0.35±0.12	-35.19 (-0.26 to -0.12)	0.000 (1.372)	0.071 (0.402)	0.012 (0.527)
dy SF	0.68±0.24	0.82±0.24	-19.12 (0.05 to 0.20)	0.75±0.25	1.02±0.10	34.67 (0.18 to 0.34)	0.63±0.22	0.67±0.24	6.35 (-0.02 to 0.11)	0.000 (1.188)	0.000 (1.127)	0.000 (0.731)
Tc ang SF	0.91±0.37	1.04±0.31	14.29 (0.05 to 0.20)	0.82±0.30	1.48±0.29	80.49 (0.55 to 0.78)	1.15±0.47	1.34±0.36	15.65 (0.04 to 0.33)	0.000 (1.765)	0.000 (0.745)	0.000 (1.281)
Tc/Lg ang SF	1.12±0.32	1.18±0.37	5.36 (0.01 to 0.12)	1.02±0.23	1.46±0.16	43.14 (0.35 to 0.53)	1.37±0.44	1.53±0.26	10.95 (0.02 to 0.28)	0.000 (1.387)	0.000 (0.943)	0.000 (1.009)
Fall SF	0.65±0.31	0.52±0.22	-18.46 (-0.18 to -0.05)	0.61±0.29	0.33±0.15	-44.26 (-0.35 to -0.19)	0.57±0.29	0.33±0.19	-42.11 (-0.31 to -0.17)	0.000 (1.780)	0.007 (0.557)	0.009 (0.544)
dx Ld	0.96±0.16	1.01±0.74	4.17 (0.01 to 0.08)	1.03±0.22	1.32±0.24	27.18 (0.19 to 0.38)	0.98±0.16	1.15±0.25	16.33 (0.07 to 0.26)	0.000 (1.247)	0.000 (0.993)	0.000 (0.745)
Ld St	0.94±0.66	1.35±0.42	43.62 (0.24 to 0.57)	0.60±0.53	1.35±0.48	125.00 (0.52 to 0.98)	1.31±0.48	1.43±0.53	9.16 (-0.02 to 0.26)	0.000 (1.419)	0.000 (0.706)	0.000 (0.853)
Fall Ld	1.05±0.66	0.64±0.42	-39.05 (-0.57 to -0.24)	1.40±0.65	0.64±0.48	53.57 (-0.98 to -0.52)	0.68±0.51	0.56±0.53	-17.65 (-0.26 to 0.02)	0.000 (1.419)	0.000 (0.706)	0.000 (0.853)
Score	7.06±1.85	9.01±1.30	27.62 (1.57 to 2.33)	6.20±2.40	11.80±1.21	90.32 (4.88 to 6.13)	8.92±1.38	10.85±1.50	21.64 (1.49 to 2.37)	0.000 (3.608)	0.000 (1.167)	0.000 (1.964)

Note: (Tc/Lg ang TO) Trunk/legs angle in take-off; (Att ang FF) Attack angle in first flight; (Am/Tc ang FF) Arm/trunk angle in first flight; (Tc/Lg ang FF) Trunk/legs angle in first flight; (dy SF) Vertical displacement in second flight; (Tc ang SF) Trunk angle in second flight; (Tc/Lg ang SF) Trunk/legs angle in second flight; Fall SF; (dx Ld) Landing Distance; (Ld St) Landing Stability; (Fall Ld) fall in landing; Score.

Table 8
Groups, Bonferroni Post Hoc of Technical Variables.

Measures	Groups		Change (%) (95% CI)	Standard Error	Sig.	Effect Size (*dz*)
Tc/Lg ang TO	Modeling	Simulation	-3.96 (-0.16 to -0.01)	0.037	0.157	0.467
	Modeling	Traditional	-16.83 (-0.03 to 0.13)	0.037	0.533	0.154
	Simulation	Traditional	-13.4 (0.03 to 0.21)	0.037	0.004	3.133
Att ang FF	Modeling	Simulation	13.97 (-0.38 to 0.16)	0.041	0.407	0.194
	Modeling	Traditional	25.74 (0.7 to 0.27)	0.041	0.000	5.733
	Simulation	Traditional	13.68 (0.12 to 0.21)	0.041	0.022	3.700
Am/Tc ang FF	Modeling	Simulation	24.24 (0.02 to 0.19)	0.034	0.004	4.666
	Modeling	Traditional	10.61 (-0.04 to 0.12)	0.034	0.757	0.098
	Simulation	Traditional	-18.07 (-0.15 to 0.1)	0.034	0.104	0.501
Tc/Lg ang FF	Modeling	Simulation	-3.73 (-0.33 to -0.04)	0.060	0.006	4.395
	Modeling	Traditional	14.18 (-0.03 to 0.25)	0.060	0.201	0.326
	Simulation	Traditional	17.27 (0.15 to 0.44)	0.060	0.000	6.976
dy SF	Modeling	Simulation	33.70 (0.13 to 0.32)	0.039	0.000	8.321
	Modeling	Traditional	19.57 (0.03 to 0.22)	0.039	0.003	4.750
	Simulation	Traditional	-21.31 (-0.19 to -0.01)	0.039	0.035	3.571
Tc ang SF	Modeling	Simulation	9.70 (-0.25 to 0.06)	0.065	0.438	0.189
	Modeling	Traditional	29.85 (0.02 to 0.33)	0.065	0.020	3.869
	Simulation	Traditional	22.31 (0.11 to 0.42)	0.065	0.000	5.913
Tc/Lg ang SF	Modeling	Simulation	-4.50 (-0.34 to -0.07)	0.057	0.001	5.300
	Modeling	Traditional	18.94 (-0.04 to 0.22)	0.057	0.363	0.348
	Simulation	Traditional	22.46 (0.16 to 0.43)	0.057	0.000	7.500
Fall SF	Modeling	Simulation	16.40 (-0.09 to 0.22)	0.045	1.000	0.012
	Modeling	Traditional	-55.74 (-0.22 to -0.01)	0.045	0.038	3.562
	Simulation	Traditional	-58.33 (-0.24 to -0.02)	0.045	0.011	4.156
dx Ld	Modeling	Simulation	12.61 (0.02 to 0.18)	0.033	0.006	4.608
	Modeling	Traditional	23.53 (0.10 to 0.26)	0.033	0.000	8.217
	Simulation	Traditional	12.5 (0.01 to 0.16)	0.033	0.040	3.608
Ld St	Modeling	Simulation	-5.74 (-0.63 to -0.15)	0.097	0.000	5.710
	Modeling	Traditional	-0.17 (-0.40 to 0.06)	0.097	0.237	0.306
	Simulation	Traditional	-5.43 (-0.01 to 0.45)	0.097	0.072	0.587
Fall Ld	Modeling	Simulation	12.07 (0.15 to 0.63)	0.097	0.000	5.710
	Modeling	Traditional	0.17 (-0.06 to 0.40)	0.097	0.237	0.306
	Simulation	Traditional	5.54 (-0.45 to 0.01)	0.097	0.072	0.587
Score	Modeling	Simulation	8.05 (-1.55 to -0.21)	0.276	0.005	4.528
	Modeling	Traditional	23.62 (0.29 to1.63)	0.276	0.002	4.958
	Simulation	Traditional	16.94 (1.18 to 2.51)	0.276	0.000	9.487

Note: (Tc/Lg ang TO) Trunk/legs angle in take-off; (Att ang FF) Attack angle in first flight; (Am/Tc ang FF) Arm/trunk angle in first flight; (Tc/Lg ang FF) Trunk/legs angle in first flight; (dy SF) Vertical displacement in second flight; (Tc ang SF) Trunk angle in second flight; (Tc/Lg ang SF) Trunk/legs angle in second flight; Fall SF; (dx Ld) Landing Distance; (Ld St) Landing Stability; (Fall Ld) fall in landing; Score. Flight; (Tc ang SF) Trunk angle in second flight; (Tc/Lg ang SF) Trunk/legs angle in second flight; Fall SF; (dx Ld) Landing Distance; (Ld St) Landing Stability; (Fall Ld) fall in landing; Score.

Table 9

Groups × Time, Bonferroni Post Hoc of Technical Variables (Differences Pre-test vs Post-test).

Measures	Groups		Change (%) (95% CI)	Standard Error	Sig.	Effect Size (*dz*)
Δ TO ang SB	Modeling	Simulation	-30.00 (-0.42 to -0.18)	0.048	0.000	1.896
	Modeling	Traditional	-26.67 (-0.38 to -0.15)	0.048	0.000	1.413
	Simulation	Traditional	3.30 (-0.08 to 0.15)	0.048	1.000	0.333
Δ Tc/Lg ang TO	Modeling	Simulation	-23.33 (-0.35 to -0.12)	0.047	0.000	1.231
	Modeling	Traditional	-27.78 (-0.39 to -0.16)	0.047	0.000	2.256
	Simulation	Traditional	-4.40 (-0.16 to 0.07)	0.047	1.000	0.275
Δ Att ang FF	Modeling	Simulation	-30.00 (-0.45 to -0.15)	0.061	0.000	0.859
	Modeling	Traditional	-43.33 (-0.58 to -0.29)	0.061	0.000	0.664
	Simulation	Traditional	-13.30 (-0.28 to 0.01)	0.061	0.091	0.156
Δ Tc/Lg ang FF	Modeling	Simulation	-26.67 (-0.44 to -0.09)	0.073	0.001	1.309
	Modeling	Traditional	-20.00 (-0.38 to -0.02)	0.073	0.022	0.843
	Simulation	Traditional	6.70 (-0.11 to 0.24)	0.073	1.000	0.300
Δ Fall FF	Modeling	Simulation	1.11 (-0.11 to 0.13)	0.049	1.000	0.151
	Modeling	Traditional	13.33 (0.01 to 0.25)	0.049	0.022	0.843
	Simulation	Traditional	12.22 (0.01 to 0.24)	0.049	0.041	0.577
Δ dy SF	Modeling	Simulation	-22.22 (-0.35 to -0.09)	0.053	0.000	1.681
	Modeling	Traditional	-13.33 (-0.26 to 0.01)	0.053	0.040	0.580
	Simulation	Traditional	8.90 (-0.04 to 0.22)	0.053	0.292	0.414
Δ Tc ang SF	Modeling	Simulation	-47.78 (-0.67 to -0.28)	0.080	0.000	1.334
	Modeling	Traditional	-53.33 (-0.73 to -0.34)	0.080	0.000	0.546
	Simulation	Traditional	-5.60 (-0.25 to 0.14)	0.080	1.000	0.308
Δ Tc/Lg ang SF	Modeling	Simulation	-28.89 (-0.45 to -0.12)	0.068	0.000	0.885
	Modeling	Traditional	-37.78 (-0.54 to -0.21)	0.068	0.000	2.128
	Simulation	Traditional	-8.90 (-0.25 to 0.08)	0.068	0.585	0.531
Δ Fall SF	Modeling	Simulation	2.77 (-0.10 to 0.15)	0.051	1.000	0.126
	Modeling	Traditional	15.00 (0.03 to 0.27)	0.051	0.012	2.121
	Simulation	Traditional	12.20 (0.01 to 0.25)	0.051	0.054	0.759
Δ dx Ld	Modeling	Simulation	-12.22 (-026 to 0.02)	0.057	0.102	0.533
	Modeling	Traditional	-24.44 (-0.38 to -0.11)	0.057	0.000	1.006
	Simulation	Traditional	-22.20 (-0.26 to 0.02)	0.057	0.102	0.533
Δ Ld St	Modeling	Simulation	-63.33 (-0.95 to -0.32)	0.129	0.000	2.136
	Modeling	Traditional	-34.44 (-0.66 to -0.03)	0.129	0.026	0.031
	Simulation	Traditional	28.90 (-0.02 to 0.60)	0.129	0.081	0.560
Δ Fall Ld	Modeling	Simulation	63.33 (0.32 to 0.95)	0.129	0.000	0.533
	Modeling	Traditional	34.44 (0.03 to 0.66)	0.129	0.026	0.577
	Simulation	Traditional	-28.90 (-0.60 to 0.02)	0.129	0.081	0.315
Δ Score	Modeling	Simulation	-36.66 (-4.75 to -2.76)	0.374	0.000	2.480
	Modeling	Traditional	-34.64 (-4.55 to -2.74)	0.374	0.000	2.527
	Simulation	Traditional	2.22 (-0.88 to 0.93)	0.374	1.000	0.606

Note: (Tc/Lg ang TO) Trunk/legs angle in take-off; (Att ang FF) Attack angle in first flight; (Am/Tc ang FF) Arm/trunk angle in first flight; (Tc/Lg ang FF) Trunk/legs angle in first flight; (dy SF) Vertical displacement in second flight; (Tc ang SF) Trunk angle in second flight; (Tc/Lg ang SF) Trunk/legs angle in second flight; Fall SF; (dx Ld) Landing Distance; (Ld St) Landing Stability; (Fall Ld) fall in landing; Score.

The results of the ANOVA repeated measure, for the kinematic variables (Table 4), revealed very significant difference during the studied vaulting phases (i.e., take off, first flight, second flight and landing). Within groups analysis showed that the three groups improved their kinematic variables throughout the diverse phases of vaulting such as distance in landing and stability. Also, between groups showed a significant difference in favour to MG (Table 5). Similarly, groups × time interaction presented a very significant difference (Table 6).

Likewise, for the technical variables, ANOVA repeated measure results (Table 7) showed very significant difference during technical execution. The between groups pairwise comparison (i.e., Bonferroni post hoc), for technical variables, presented significant difference in favour of MG (Table 8). Equally, groups × time interaction results (i.e., differences pre-test vs post-test), for the technical variables, showed significant variance in the learning (Table 9).

DISCUSSION

This study aimed to compare the effects of different teaching / learning strategies (i.e., verbal feedback, video feedback with modeling, and video feedback with simulation) on performing basic vaulting skills in the vault table. After 21 teaching / learning sessions, the primary results showed that the MG enhanced significantly these performances ($p<0.01$) better than SG and TG. This result demonstrated the effectiveness of learning by video modeling procedures for the acquisition and improvement of vaulting skills for students. Indeed, several studies (Horn, Williams, & Scott, 2002; Baudry et al., 2006) demonstrated that video viewing of a model or its own performance is efficient for immediate and long-term learning (Guadagnoli, Holcomb, & Davis, 2002). SG revealed positive impact on performances ($p<0.01$) as compared to TG. Nevertheless, after receiving the learning by classical teaching / learning based on verbal-feedback, TG also enhanced the appropriate movement patterns, which subsequently leads to better outcomes (Hebert & Landin, 1994). However, this group did not use any video support (i.e., self-modeling, expert-modeling and model-overlay or motion simulation), but they may have information, during the vault learning, from their peers who perform the same exercises during the session, this is "inexperienced modeling”.

The kinematic study of take-off phase on springboard showed that the take-off angle of attack reveals a significant difference between MG and TG. Also, in this phase, the trunk/legs angle presented a significant difference between groups where MG had the best posture. In fact, MG seems to perform a fast and intense impact on springboard compared to other groups. This enhancement appears to be due to the different forms of video feedback (i.e., expert-modeling, self-modeling and model’s superposition), that provide significant information of take-off angle to optimize their performance (Giroud & Debû, 2004; Le Naour et al., 2019; Palao, Hastie, Cruz, & Ortega, 2013; Potdevin et al., 2018). Indeed, it is noted that learning with video modeling of gymnastic skills has a positive effect on improving student performance. These results are confirmed by the research of Baudry et al. (2006) who argue that the video modeling helps the gymnast to develop a cognitive representation of movement. So, by viewing sequences, the subject will analyse the steps necessary to achieve the motor performance.

Similarly, the attack angle in the first flight was significantly increased in favour of MG more than SG and TG. Likewise, SG improved the support phase better than TG. This proves that the video feedback helps students enormously to build a mental image of the gesture (Rymal & Ste-Marie, 2017).

Furthermore, vertical displacement, in the second flight, has significantly increased for MG better than SG and TG. It appears that the fast and intense impact on springboard and the support phase pushing arms might increase height of 2nd flight for MG (Veličković et al., 2011).

Trunk angle in second flight was also more important for the MG compared to the TG. Similarly, for SG and TG, we note better trunk straightening for SG. The trunk straightening in the second flight is better for MG and SG, due to a better understanding / representation of the movement (Le Naour et al., 2019; Potdevin et al., 2018; Rymal & Ste-Marie, 2017). In addition, our investigation showed that the trunk/legs angle, in second flight, has been also improved for MG vs TG and for SG vs TG. Perhaps an excellent 2nd flight depends on the characteristics of previous phases (Aticović & Smaljović, 2011; Heinen, Vinken, Jeraj & Velentzas, 2013).

Lastly, in kinematic study, the MG displayed better improvements in landing distance followed by SG compared to TG. The video observation of a reference model (i.e., expert gymnast) is interesting for several reasons. Indeed, when the model is an expert gymnast, the convenient skill execution on performance was served as a source of information for observers (Rymal & Ste-Marie, 2017). In this context, the expert-model provides the learner with information to reach the task goal (Magill & Schoenfelder-Zohdi, 1996; Rymal & Ste-Marie, 2017). A visual model may serve as the best mechanism for encoding and retrieving information from memory (Meany, 1994). In addition, the simulation model is an interactive feedback with error correction and technical optimization. It allows students to learn with initiative, instead fo passive memorization, and promotes understanding and motion knowledge (Zhou, 2016).

Otherwise, the most important finding of the technical study is the advantage of video-feedback with model's superposition, which allows a better perfection in the technical learning (Baudry et al., 2006; Le Naour et al., 2019). The results signposted a better improvement in the performance for MG compared to SG and TG. For instance, the take-off phase shows that MG is more effective in reducing the deduction score than SG and TG. Also, the spring board take-off angle score was increased in favour of MG in comparison with SG and TG. Similarly, MG increase their trunk/legs angle score, in take-off, than the other groups (i.e., SG and TG). Moreover, we note an increase for SG compared to TG. This enhancement can be allocated to the different forms of video feedback (i.e., expert-modeling, self-modeling and model's superposition), that provide significant information to optimize performance (Giroud & Debû, 2004; Le Naour et al., 2019; Palao et al., 2013; Potdevin et al., 2018).

Other enhancement was noted in favour of MG, we found an increase of the attack angle score at the first flight in comparison with SG and TG. Similarly, the largest enhancement for arm/trunk angle score was noted in the MG compared to SG and TG.

Regarding, the vault second flight, MG increased his score better than the others groups (i.e., SG and TG) in vertical displacement and trunk angle. MG and SG reached better score compared to TG. Also, in the landing phase score (i.e., stability and landing distance), MG is more effective in increasing his score followed by SG and TG.

In an earlier study (Amara et al., 2015), the modeling form has proven in promoting student learning technical gesture. So, the technical score of MG is significantly higher than the SG and TG. Nevertheless, SG improved his score better than TG.

The repeated observation of a reference model would facilitate the development of internal reference (Magill & Schoenfelder-Zohdi, 1996) or cognitive representation (Carroll & Bandura, 1990), necessary for appropriation of essential coordination to perform a complex motor skill. In addition, the information attained by self-modeling, can influence the development of a memory representation of the skill and facilitate technical faults correction and subsequent learning (Giroud & Debû, 2004; Palao et al., 2013; Rymal & Ste-Marie, 2017).

This finding has been validated as well, in previous studies in the field of motor skills particularly by the study of Carroll and Bandura (1987). The authors prove that the observation of an external model is effective at the beginning of the new coordination acquisition that consists of a complex motor sequence. This will allow students to have a better understanding of the driving task and monitor the progress because after viewing the images, they are better able to understand the movement, particularly in terms of sequence. In a second phase, knowledge of performance, delivered through a video feedback, enables the refinement of the internal model (Le Naour et al., 2019; Potdevin et al., 2018; Rymal & Ste-Marie, 2017). Students observe the expert-model, the self-model, the model's superposition and or the model simulation then practise and remember the skill information, which is used to correct their movement and enhance their technical abilities compared to students with verbal feedback (Clark & Ste-Marie, 2007; Giroud & Debû, 2004; Palao et al., 2013). In fact, video modeling and video feedback for gymnasts are highly effective for increasing the execution of a skill that has already been learned at a basic performance level, as was found by Rikli and Smith (1980).

It has been previously shown that deep learning with a video feedback using model's superposition and / or model's simulation is better than verbal feedback in teaching / learning gymnastics skills (Baudry et al., 2006; Boyer et al., 2009; Le Naour et al., 2019; Potdevin et al., 2018; Zhou, 2016). Therefore, using video modeling with model's superposition provides educators with pedagogical tools to promote a deeper understanding of the human movement and its relationship with athletic performance.

CONCLUSIONS

The findings of this study highlighted the positive effect of the three methods (i.e., verbal feedback, video feedback with modeling, and video feedback with simulation) in improving the learning and performance of direct piked vault in the vault table. However, students assigned to the video feedback have reported a greater enhancement in comparison with students assigned to the other methods, particularly video feedback with modeling. The outcome of our study gives the ample evidence that ICT plays a key role in teaching technical skills for physical education students and demonstrated the benefits of using digital technologies in physical education when integrated into a pedagogical approach. This enables the educators and the students to find the right solution to a similar problem or situation. For instance, it is important for educators and coaches to integrate video learning activities (i.e., self-modeling, expert-modeling, model's superposition and model's simulation) in students / gymnasts training programs to give learners the opportunities to improve the specific knowledge through video modeling.

Finally, the present results have an important practical implication for students / gymnasts, teachers / coaches who can benefit from the importance of model's superposition and simulation process that revealed effectiveness of technologies in the pedagogical field of gymnastics and in the enhancement of athletic performance.

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Corresponding author:

Bessem Mkaouer
Higher Institute of Sport and Physical Education of Ksar Saïd, Manouba University, Manouba, Tunisia
Email: bessem_gym@yahoo.fr
Phone: +216 23066716
Fax: +216 71937437

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