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Evaluation of psychomotor skills acquired for surgery by veterinary students using biological simulators
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EVALUATION OF PSYCHOMOTOR SKILLS ACQUIRED FOR SURGERY BY VETERINARY STUDENTS USING BIOLOGICAL SIMULATORS

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SUMMARY

This study aimed to evaluate the acquisition of psychomotor skills using biological simulators in surgical practices by third-year students of Veterinary Medicine at the Autonomous Metropolitan University, Mexico City. The Gibson Spiral Test was applied pre- and post-practice to 171 students (92 women, 79 men) between 18 and 38 years old. The techniques practiced were: ligature, synthetic skin, enterotomy, enterectomy, gastrostomy, cystotomy, endotracheal tube placement, permanent intravenous catheter. Students were classified as fast-accurate (FA), fast- inaccurate (FI), slow-accurate (SA), and slow-inaccurate (SI). The test duration decreased by 7.91s (P<0.05) post-practice (compared to pre-practice), and there was no difference in the number of errors pre- and post-practice (P>0.10). There were differences among the fast (F) and slow (S) students pre-practice (P<0.0001). In post-practice the students for FI (4.23) presented more errors than SI (3.40) (P<0.0001). In pre practice results also were differences (P<0.0001) between the fast and the slow; in the slow, less time was used by the SA (49.38s). There no differences (P<0.0001) in post practice errors between accurate (FA and SA) and against inaccurate (FI and SI) students, nor regarding gender (P>0.10). Comparing practice time difference (P=0.007) between slow and fast in the pre-practice, men performed more quickly in pre-practice and after practice (P<0.0001), with no differences in mean number of errors pre- (P=0.662) and post-practice (P=0.962). We conclude that students showed progress in acquiring motor skills, by increasing their speed and reducing errors, thus increasing the number of fast and accurate students. Men outperformed women.

Introduction

Universities with veterinary medicine programs frequently use live animals for teaching surgical techniques, for the student to learns through practice in surgery courses (Smeak *et al*., 1994). The limitations of using live animals and the need to train veterinary surgeons have modified teaching techniques (Smeak, 1989), with technological advances that have replaced live animals to meet the requirements of animal care and ethics, and to deal with objections towards using healthy animals for developing surgical skills. In this regard, different simulated biological models have been developed (Anastakis *et al*., 2000). These may be virtual simulators for basic surgical skills (Felsher *et al*., 2005; Aggarwal *et al*., 2006; Windsor *et al*., 2008), or tissues collected from ethically slaughtered animals (Debes *et al*., 2010). The models are used to develop and refine the technical skills of students to the appropriate level of learning and preparation to allow the treatment of live patients (Smeak *et al*., 1991; HSVMA, 2009).

The key advantage of these models is the generation of basic surgical skills and abilities (Torres *et al*., 2003; Tefera, 2011). The benefits of biological models are that the student can spend more time learning about important aspects of the techniques and surgical procedures, repeating the procedure as many times as is necessary in order to obtain the required skill. This has the advantage of minimizing the amount of experience gained on live animals (Smeak *et al*., 1994). The interest in developing biological models using anatomical parts lies in the possibility of directly using these analogies in biological processes, describing performance, and also reducing operational costs and time, compared with the use of living animals (Archundia, 1992; Knight, 2011, 2012b).

In order to assess surgical skills in students, psychomotor tests that measure the speed, accuracy, and muscle response to a controlled stimulus have been used (Gibson, 1964; Harris *et al*., 1994). In this study we utilised the Gibson Spiral Maze Test, because it has the advantage of having little connection with the degree of

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EVALUACIÓN DE HABILIDADES SICOMOTORAS PARA CIRUGÍA ADQUIRIDAS POR ESTUDIANTES DE VETERINARIA UTILIZANDO SIMULADORES BIOLÓGICOS

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RESUMEN

Este estudio pretende evaluar la adquisición de habilidades sicomotoras utilizando simuladores biológicos en prácticas quirúrgicas de estudiantes de tercer año de Medicina Veterinaria en la Universidad Autónoma Metropolitana, Ciudad de México. El Test de la Espiral de Gibson fue aplicado pre- y post-práctica a 171 estudiantes (92 mujeres, 79 hombres) de 18-38 años de edad. Las técnicas practicadas fueron: ligadura, piel sintética, enterotomía, enterectomía, gastrostomía, cistostomía, colocación de tubo endotraqueal y catéter venoso permanente. Se clasificó los estudiantes como rápido-preciso (RP), rápido-impreciso (RI), lento-preciso (L-P) y lento-impreciso (L-I). La duración del test disminuyó en 7,91s (P<0,05) en post-práctica (comparado a pre-práctica), y no hubo diferencia en el número de errores en pre- y post-práctica (P>0,10). Hubo diferencias entre estudiantes rápidos ® y lentos (L) en pre-práctica (P<0,0001). En post-práctica los estudiantes RI presentaron menos (P<0,0001) errores (4,23) que LI (3,40). En pre-práctica también hubo diferencias (P<0,0001) entre R y L; en los L menos tiempo emplearon los LP (49,38s). No hubo diferencias (P<0,0001) en errores post-práctica entre estudiantes precisos (LP, RP) e imprecisos (LI, RI), ni entre géneros (P>0,10). Comparando la diferencia en tiempo de práctica (P=0,007) entre lentos y rápidos en pre-práctica, los hombres fueron más rápidos en pre- y post-práctica (P<0,0001), sin diferencias en el promedio de errores pre- (P=0,662) y post-práctica (P=0,962). Se concluye que los estudiantes mostraron progresos en la adquisición de habilidades motoras al aumentar su velocidad y reducir errores, aumentando así el número de estudiantes rápidos y precisos. Los hombres superaron a las mujeres.

AVALIAÇÃO DE HABILIDADES PSICOMOTORAS PARA CIRURGIA ADQUIRIDAS POR ESTUDANTES DE VETERINÁRIA UTILIZANDO SIMULADORES BIOLÓGICOS

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RESUMO

Este estudo pretende avaliar a aquisição de habilidades psicomotoras utilizando simuladores biológicos em práticas cirúrgicas de estudantes de terceiro ano de Medicina Veterinária na Universidade Autônoma Metropolitana, Cidade do México. O Teste da Espiral de Gibson foi aplicado pré e pós-prática a 171 estudantes (92 mulheres, 79 homens) de 18 a 38 anos de idade. As técnicas praticadas foram: ligadura, pele sintética, enterotomia, enterectomia, gastrostomía, cistostomia, colocação de tubo endotraqueal e cateter venoso permanente. Classificaram-se os estudantes como rápido-preciso (RP), rápido-impreciso (RI), lento-preciso (L-P) e lento-impreciso (L-I). A duração do teste diminuiu em 7,91s (P<0,05) em pós-prática (comparado a pré--prática), e não houve diferença no número de erros em pré- e pós-prática (P>0,10). Houve diferenças entre estudantes rápidos® e lentos (L) em pré-prática (P<0,0001). Em pós-prática os estudantes RI apresentaram menos (P<0,0001) erros (4,23) que LI (3,40). Em pré-prática também houve diferenças (P<0,0001) entre R e L; nos L menos tempo empregaram os LP (49,38s). Não houve diferenças (P<0,0001) em erros pós-prática entre estudantes precisos (LP, RP) e imprecisos (LI, RI), nem entre gêneros (P>0,10). Comparando a diferença em tempo de prática (P=0,007) entre lentos e rápidos em pré-prática, os homens foram mais rápidos em pré e pós-prática (P<0,0001), sem diferenças na média de erros pré (P=0,662) e pós-prática (P=0,962). Conclui-se que os estudantes mostraram progressos na aquisição de habilidades motoras ao aumentar sua velocidade e reduzir erros, aumentando assim o número de estudantes rápidos e precisos. Os homens superaram as mulheres.

manifest neuroticism and behavioural disorders and therefore does not cause distortion attitudes that lead to spontaneous responses, and can be used to identify professional skills in surgery (e.g. laparoscopy, endoscopy), psychiatry, anesthesiology and other specialties by evaluating skills and hand-eye coordination (Harris *et al*., 1994; Stefanidis *et al*., 2006; Knight, 2012a). Other similar tests such as the Crawford Small Parts Dexterity Test (Boyle and Santelli, 1986) and the Space Relation Test (Coy *et al*., 2003) quantify execution time, manual dexterity, and manual skills. Thus, using the Gibson Spiral Maze Test, the aim of this study was to evaluate the training level in basic surgical techniques acquired with biological simulators in students attending their third year of veterinary medicine in a Mexican university.

Material and Methods

Evaluation of biological simulators in veterinary medicine

The study was conducted at the external veterinary clinic of the *Universidad Autónoma Metropolitana* – Xochimilco, located in Tulyehualco, Mexico City, in the period from May 2008 to December 2010. The Gibson Spiral Maze Test was applied to 171 students (92 women and 79 men), between 18 and 38 years old, attending their third year of the program in veterinary medicine at the same university. Before the tests, all students received theoretical and practical training in surgical procedures, such as synthesis of skin, enterotomy, gastrostomy, cystostomy, endotracheal tube placement and permanent intravenous catheter, using learning methodology based on models and the resolution of simulated cases.

During the Gibson Spiral Maze Test, the duration of the test and number of errors were recorded (Gibson, 1964, 1969), quantifying the time from when the student began to draw the line, and stopping the timer at the end of the spiral. The students were subsequently grouped into five teams (surgeon, assistant surgeon, instrumentalist, anesthetist and circulating) and performed surgical practices using biological simulators (pig

TABLE I
TIME TAKEN TO PERFORM THE GIBSON SPIRAL MAZE TEST AND NUMBER OF ERRORS BEFORE AND AFTER SURGICAL PRACTICE USING BIOLOGICAL SIMULATORS

Practice	Time (sec)	Errors
Before	39.34 [a]	1.74 [a]
After	31.43 [b]	1.53 [a]
Coefficient of variation	29.14	125.49
Kruskal Wallis Test		
χ^2	45.35	0.0007
DF	1	1
$P<\chi^2$	<0.0001	0.97

[a,b] Values are considered statistically significant (P<0.05).

TABLE II
TIME TAKEN TO PERFORM THE GIBSON SPIRAL MAZE TEST AND NUMBER OF ERRORS ACCORDING TO CLASSIFICATION GROUP * BEFORE AND AFTER PRACTICE WITH BIOLOGICAL SIMULATORS

Classification		Time (sec)	Errors
		Before practice	
Fast – Accurate	(n=52)	32.57 [a]	0.42 [c]
Fast – Inaccurate	(n=47)	29.	4.23 [a]
Slow – Accurate	(n=52)	49.38 [b]	0.19 [c]
Slow – Inaccurate	(n=20)	52.82 [b]	3.40 [b]
Coefficient of variation		16.26	72.99
Kruskal Wallis Test			
χ^2		126.52	134.56
DF		3	3
$P>\chi^2$		<0.0001	<0.0001
		After practice	
Fast – Accurate	(n=61)	26.16 [a]	0.49 [a]
Fast – Inaccurate	(n=38)	23.98 [a]	3.53 [b]
Slow – Accurate	(n=42)	38.47 [b]	0.31 [a]
Slow – Inaccurate	(n=30)	41.71 [c]	2.83 [b]
Coefficient of variation		17.23	83.88
Kruskal Wallis Test			
χ^2		125.7057	132.41
DF		3	3
$P>\chi^2$		<0.0001	<0.0001

* Defined by accuracy and speed with which students performed surgical procedures pre-practice.
[a,b] Values are considered statistically significant (P<0.05).

organs) that were obtained from animals slaughtered humanely in accordance with the Official Mexican Standard (NOM-033-ZOO-1995) that regulates the slaughter of domestic animals and wildlife. The techniques practiced were synthesis of skin, enterotomy and enterectomy, splenectomy, cystotomy, airways and permeable intravenous lines. After completing the practice sessions, the Gibson Spiral Maze Test was reapplied. As the tissues used as biological simulators were obtained from animals for slaughter, they were not preserved and at the end of the practice sessions they were incinerated.

The number of errors and the time taken to perform the spiral test before and after surgical practice were assessed by gender and according to the classification group, which was based on accuracy and the speed with which procedures were performed before surgical practice: fast - accurate (FA), fast - inaccurate (FI), slow - accurate (SA), and slow - inaccurate (SI). The results were analysed with the Kruskal-Wallis test and the means were compared with Tukey's test (Herrera and Barreras, 2005).

Results and Discussion

The psychomotor skills of students improved after practice, which reduced the time taken to do the spiral by 7.91 seconds, a reduction of 20.3% in time, with no difference in the number of errors (Table I). This shows the benefits of practice with simulators.

When students were classified into groups, differences in time taken to make the spiral before and after practice were detected (Table II), particularly in students classified as fast compared to the slow group, indicating that practice drastically changes the skills of students. This was also manifested in the number of errors in students classified as inaccurate: before the practice the FI group made the most errors, but following practice the two inaccurate groups (FI and SI) made a similar number of errors. In general, the time taken to complete the spiral showed the same trend after practice, and was shorter.

The mean age by gender was similar (female= 22.75 years; male= 22.64 years), and therefore the comparison between men and women was valid. Women took longer to draw the spiral than men, both before and after practice (Table III). Following the use of simulators, the time taken for the spiral test was reduced in both men and women, indicating evidence of learning. There was no difference in the number of errors made during practice, indicating that gender does not affect this variable.

The use of simulation models as an educational method for medical procedures is growing rapidly, with significant improvements in reliability, both visual and tactile. This allows for competency assessment and accreditation of skills (Michelson and Manning, 2008). Surgical training has recently undergone various changes, owing to student interest in acquiring surgical skills outside the operating room through simulation of surgical procedures, using artificial or cadaver tissues, animal models and virtual reality simulation, thus allowing the full transfer of the skills learned and practiced by students in the laboratory to the operating room (Torkington *et al.*, 2000).

TABLE III
TIME TAKEN TO PERFORM THE GIBSON SPIRAL MAZE TEST AND NUMBER OF ERRORS ACCORDING TO GENDER BEFORE AND AFTER PRACTICE WITH BIOLOGICAL SIMULATORS

Classification	Time (sec)	Errors
	Before practice	
Women	42.22 [a]	1.847 [a]
Men	35.99 [b]	1.632 [a]
Coefficient of variation	28.03	126.91
Kruskal-Wallis Test		
χ^2	11.55	0.190
DF	1	1
$P>\chi^2$	0.0007	0.6622
	After practice	
Women	34.32 [a]	1.620 [a]
Men	28.05 [b]	1.456 [a]
Coefficient of variation	27.12	123.5
Kruskal Wallis Test		
χ^2	21.53	0.002
DF	1	1
$P>\chi^2$	< 0.0001	0.9628

[a,b] Values are considered statistically significant (P<0.05).

The use of simulators is a fast, efficient way to teach, allowing students to acquire surgical skills at low cost (Michelson and Manning, 2008; Korndorffer *et al*., 2012). Biological models have the further benefits of being easily replicable in other schools, and have the benefit of practice on biological tissues, allowing students to develop tactile perception in a real surgical procedure (Adrales *et al*., 2003, 2004). Several studies in which simulators were used to suture gastrointestinal organs have demonstrated that, when compared with practice on live animals, the duration of surgery was reduced (Smeak *et al*., 1994). The benefits of teaching methods with biological simulators include greater compliance with the regulations of each country as well as a reduction in objections by students and faculty over the use of dead animals, which in turn develops a sense of ethics and welfare in the students in their future professional practice as well as achieving time and cost savings (Knight, 2012a), consistent with the findings of the current study.

In order to demonstrate the value of simulation in laparoscopic surgery (Derossis *et al*., 1998; Fried *et al*., 2004), the use of simulators in laparoscopic cholecystectomy (Gauger *et al*., 2010; Sroka *et al*., 2010) and urethrovesical anastomosis (Shiu-Dong *et al*., 2010) resulted in a shorter time taken to perform the procedure in real patients, compared with students who only practiced without the use of simulators (Sroka *et al*., 2010). Several reports have demonstrated that the use of virtual reality simulators decreases the time real surgical procedure (Felsher *et al*., 2005; Aggarwal *et al*., 2006; Windsor *et al*., 2008). In contrast, the trainer video box (simulator for surgical skills) showed no such benefits post-practice in laparoscopy (Debes *et al*., 2010).

A wide range of learning tools and approaches for veterinary educators are available. Many have been tested and some are innovative and have great potential (Martinsen and Jukes, 2005). Currently, there are few animal simulators designed specifically for use in veterinary education; however, as in human medicine, new testing and accreditation requirements will stimulate further development of these technologies. The models, mannequins and biological simulators allow veterinary students to practice and master the skills and techniques before working with live animals. These tools facilitate training in animal handling, blood collection, intubation, cardiopulmonary resuscitation and some surgical skills (HSVMA, 2009). In addition, growing concern over animal welfare and awareness of the need for training veterinarians in this philosophy will result in competent veterinary physicians with the necessary skills to perform their profession and care for their patients and community (Scalese and Issenberg, 2005).

It has been pointed out that a surgical curriculum based on simulators for training allows young medical students to master basic surgical skills (Naylor *et al*., 2009). Surgical educators must remain up-to-date in new education technologies and should evaluate these scientifically in current conditions, allowing objective assessments of the abilities of students (Korndorffer *et al*., 2010).

In studies in which gender was compared, it has been reported that men make more mistakes than women (Gibson, 1969), because they are less accurate in performing the test. However, the opposite was found in the present study, with no difference in number of errors according to gender, and with men being faster than women. Studies indicate that parts of the frontal lobe in the brain involved in decision-making and problem-solving are proportionally larger in women (Gibson, 1969) and that the hippocampus, which is involved in short-term memory, is also larger in women than in men (Goldstein *et al*., 2001). In other studies it has been observed that as men increase in speed, they decrease in accuracy and a comparison by gender suggested that women are slower and less accurate than men (Omar, 1991). Surgical practice with biological simulators helps to 'refine' psychomotor ability, giving greater speed and reducing the number of errors in the second test (Francis *et al*., 2001). The differences found between men and women are associated with different functions performed by each of the hemispheres of the brain. While the left side handles aspects related to language, the right determines visuo-spatial abilities (Rubia, 2005). Men show greater development of the right side of the brain from infancy, which makes them more suitable for activities such as driving or playing chess, while women more often use the left, making better use of language. These differences extend to the corpus callosum connecting the two hemispheres, which is more developed in women, making them more aware of their emotions, and other parts of the cerebral cortex, such as the nucleus of the hypothalamus, which regulates sexual activity and is larger in men than in women. Generally, women are more logical and can therefore respond appropriately when performing multiple actions at one time, while men are less competent in these tasks and are more impulsive (Rubia, 2005).

It has been reported that age should not influence the results obtained from these kinds of tests after adolescence, because by this stage the physical maturation of individuals has been completed and factors such as muscle development and its effect on the arm and the speed of execution have no influence on performance (Gibson, 1964).

Conclusions

The students showed improvement in the acquisition of psychomotor skills with biological simulators, increasing speed and reducing the number of errors. There were differences in the number of errors between men and women, men completing the test more quickly and with fewer errors.

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