Research Report

Effect of foosball practice on veterinary students' bovine artificial insemination skills

Mia Norton,[a] Annett Annandale[a,b]
[a]School of Veterinary Medicine, Murdoch University, Perth, Australia;
[b]Faculty of Veterinary Science, University of Pretoria, Pretoria, South Africa

Abstract

Live cow artificial insemination (AI) opportunities are limited at training institutions, and this study explored a novel approach to better prepare students for the task. Since the arm and wrist movement while playing foosball (FB) is like picking up the cervix during AIs, the effect of playing FB on veterinary students' AI performance was investigated. Objective was to determine if playing FB would improve students bovine AI ability through muscle memory development. Fourth year (of a 5 year course) veterinary students (n = 28) either took part in the FB cohort (n = 17) or the nonFB cohort (n = 11). The FB cohort played 30 minutes of FB 3 times/week for 8 weeks. Both cohorts then participated in AI training using bovine cadaver uteruses before they were assessed on their ability to place an AI pipette into a live cow's uterus. Although there was no difference between cohorts (p = 0.58) there was a higher proportion of successful students in the FB (0.35) compared to the nonFB cohort (0.18). Small cohort size, the fact that only 11 students completed the allocated FB play time, and participants' transrectal palpation (TRP) inexperience may have influenced the result. This should, however, not discourage further investigations into alternative teaching approaches. Furthermore, this study highlighted the importance of assessing competence for clinical skills that are required to learn new skills first (TRP in this case) before attempting to teach a new, more advanced skill (AI in this case). This is likely to be applicable for many other clinical skills.

Keywords: Artificial insemination, cattle, foosball, clinical skills training

Introduction

Bovine artificial insemination (AI) is a valuable large animal clinical skill that has an impact on cattle herd profitability, especially on dairy farms,[1] improves the genetic quality of herds,[2,3] controls disease and is cost effective compared to natural mating.[4] Inefficiency in AI can dramatically affect fertility,[4] produce variable or low calving rates and will ultimately have a substantial economic impact on farmers.[5] Although large dairy operations mostly utilize technicians for AIs, veterinarians are expected to have experience and knowledge with AI process in their role as a dairy consultant, or to efficiently implement AI programs for small scale or hobby farmers.[1] It is therefore an important skill for veterinary students to learn. Passing a pipette through the cervix for AI does not differ from passing a pipette or other instruments for diagnostic or treatment reasons and further highlights the importance of learning this skill. However, live cow training opportunities at university level are scarce.[1] Modern veterinary programs have a strong focus on the development of clinical skills,[6] with an expectation to produce graduates with advanced technical skills.[7] Developing competence in the required skills depends on opportunities for sustained, deliberate hands-on practice while learning.[7–9] Providing sufficient opportunities for skills acquisition is influenced by various factors including increased student numbers,[7,8] budget restrictions, and the welfare and ethical concerns surrounding the use of live animals for student training.[7,10] The 'five step method for teaching clinical skills'[11] outlines a method for teaching psychomotor skills in an organized and successful way that aids students. This method has its benefits in training clinical skills in medical and veterinary programs where the entirety of the skill can be observed. However, there are skills (e.g., transrectal palpation (TRP) and AI in large animal veterinary practice) that cannot be observed. Bovine AI simulators (e.g., [1]Breed'n Betsy® simulator, [2]Minitube 'Henryetta' insemination model and [3]Bovine Breeder™ AI simulator) were developed as

1. Breed'n Betsy, https://www.breednbetsy.com.au/
2. Minitube, https://www.minitube.com/catalog/en/henryetta-artificial-cow-ai-training-model-p2353/
3. Realityworx, https://www.realityworks.com/product/bovine-breeder-artificial-insemination-simulator/

CONTACT Annett Annandale **annett.annandale@murdoch.edu.au**

Citation line: Clinical Theriogenology 2023, 15, 9595, http://dx.doi.org/10.58292/CT.v15.9595

training alternatives. These simulators provide excellent additional training opportunities and help to overcome some of the challenges faced with live animal training.[12] However, limitations around implementing simulator training at teaching institutions include the expense to purchase simulators, labor, time, and intense small group teaching that is required for effective training.[12] The need to overcome restraints around teaching certain skills has led to the development of alternate approaches to skills training.[13,14] A few recent studies in veterinary education have tested a concept where learning or training outside of the main task has been used to improve performance required for the main task. One study considered how training in fine arts could improve veterinary students' observational skills when learning cytology, assuming that deconstructing art helps develop an understanding for why things look how they do and apply these skills to other images.[13] Another study, focused on physical training, identified that veterinary students who took part in a 6 week exercise program were able to more accurately perform pregnancy diagnoses (PD) via TRP in cows compared to students who did not participate in the exercise program.[14] As demonstrated,[15] alternate approaches to teaching have not only been utilized in veterinary sciences. A recently developed concept that could be applied to improve clinical skills acquisition in veterinary education is called the 'predictor micro skills concept'.[12] This concept aims to identify factors that influence a student's ability to perform a certain skill. These factors are then used to identify micro skills involved in the performance of the overall skill. Micro skills are defined as part tasks or components of the overall skill that can be learned and developed separately to the main task. Once trained in micro skills, it is expected that the training and learning of the main skill will be more efficient. This concept was based on investigations aimed at improving bovine PD via TRP.[12] If this concept is applied to bovine AI as the skill, passing an AI pipette through the cervix would be a micro skill. Since correct placement of the AI pipette into the uterus during AI is considered as one of the most challenging components of the procedure, it would be advantageous to better prepare students for this part of the AI process. Passing an AI pipette through the cervix and into the uterus is facilitated by grasping the cervix and moving it cranially,[16] actions like the wrist and hand actions during playing foosball (FB) (Figure 1). The 'predictor' in this case that is expected to enhance acquisition of the micro skill, is muscle memory produced by repeated table FB exposure. Muscle memory is the common term used to describe motor learning and motor memory.[17] Motor memory is the formation of multiple long-term memories within the nervous system,[18] produced through repeated practice of a specific motion.[19,20] Motor memory is why humans apparently never forget how to swim, ride a bike, or drive a car;[18] it allows motor skills to be performed spontaneously or in a more automatic fashion.[19] There are currently no publications investigating the effect of muscle memory development on skills acquisition in veterinary education. Activities (e.g., FB) are easy to implement at veterinary schools and could be used to improve student preparation for limited live cow AI training opportunities.

The aim was to determine the effect of 8 weeks FB bootcamp on veterinary students' ability to pass an AI pipette through the cervix and into a cow's uterus. It was hypothesized that students with exposure to FB practice are more likely to successfully pass an AI pipette through the cervix and into a cow's uterus compared to students without FB exposure.

Materials and methods

Study population and recruitment

This prospective cohort study consisted of 2 student cohorts in the 4th year of the veterinary medicine course at Murdoch University, Perth, Western Australia. All students participating had previous basic bovine TRP training within the 4th year veterinary reproduction module with no prior live cow AI training or experience nor additional TRP experience outside the veterinary course. The 2 study cohorts were the FB exposure group (G_{fb}) and the nonFB group (G_0). Participants in G_{fb} took part in an 8-week FB bootcamp, attended an AI training session and an AI assessment where the task was to place an AI pipette into the uterus of a live cow. Participants in G_0 only attended the AI training and the assessment. Participants in G_{fb} were required to be available to take part in FB practice, and must not have had any previous hand, wrist, or arm injuries. Participants in both, G_{fb} and $G_{0,}$ needed to be available for AI training and assessment.

Students were recruited to each cohort by voluntary sign up after receiving information on the project in the form of a flyer posted to the 4th year veterinary students' Facebook group. Students were able to choose whether they wanted to be part of G_{fb} or G_0. Students interested in either group were given further information in the form of an information letter. Both cohorts then attended a brief information session on the project and to sign a consent form to confirm participation in the study. Withdrawal from the study was possible for participants at any stage.

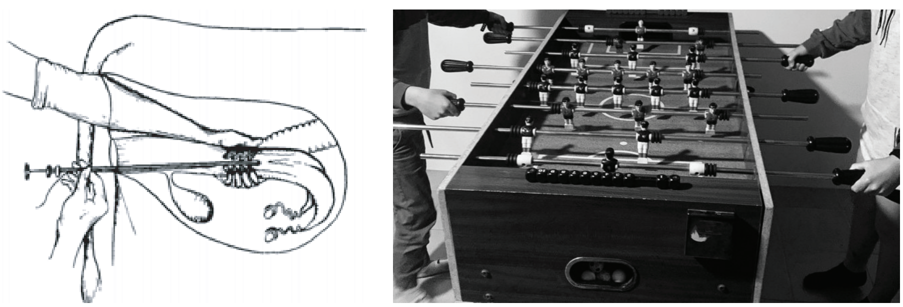

Figure 1. Hand and wrist movements during bovine artificial insemination* versus foosball
source: *https://www.journalofdairyscience.org/article/S0022-0302(89)79346-2/pdf

Foosball exposure

Participants in G_{fb} completed 8 weeks of FB practice. Two FB tables were placed in an easily accessible venue at Murdoch University. During the 8 weeks, G_{fb} participants were encouraged to play FB at least 3 times a week for 30 minutes. Students were able to use any free time to play FB (e.g., lunch breaks or between classes), and FB tables were accessible during weekends. FB tables were cleaned at the end of each week by an investigator as a COVID-19 precaution; however, students could clean the tables and handles whenever they felt necessary using the disinfectant available at each of the FB tables. A Facebook group was created for students in G_{fb} to communicate with each other about playing times, and for communication purposes between investigators and participants.

Artificial insemination training

During the last week of FB practice for G_{fb}, both cohorts (G_{fb} and G_0) participated in a 2-hour AI training session. The training session took place in a teaching laboratory at the veterinary school. Complete, fresh bovine reproductive tracts including cervix and vagina were sourced from an abattoir for use at the training session. The first half hour of the session was a lecture and a demonstration of the AI procedure by an experienced veterinarian using a fresh cadaver uterus. As this project was focused on the grasping of cervix and passing a pipette through the cervix and into the uterine body, this was the focus of AI training rather than the complete AI process. Eight abattoir-derived uteruses were hung in frames in a position resembling true anatomic positioning of the uterus in a live cow. The frames were ~ 1.5 meter high and contained a bony bovine pelvis in which the uteruses were positioned. This allowed participants to practice the AI process without being able to see the uterus, relying on feel to correctly place the pipette. The remaining fresh uteruses were laid out on a table to allow students to familiarize themselves with the structures of the cervix and uterus. Participants also had access to a video detailing the process of bovine AI (https://www.youtube.com/watch?v=H_SvuiT3GTk). After the initial explanation of the procedure, participants moved between activities and practiced the AI procedure themselves. An experienced veterinarian was available to help and provided feedback.

Cattle study population and synchronization

Nonpregnant (n = 25) cows from the Murdoch University veterinary farm were used for the AI assessment component of the project. An estrus synchronization program was implemented to ensure that cows were in estrus or proestrus for the AI assessment. Cows were kept at the Murdoch University veterinary farm in their usual surroundings for the duration of this study. Whenever cows were required by investigators, they were moved from their paddock into purpose-built cattle yards by the farm manager. Cows were moved into cattle examination crushes for any procedures. The crush facilities had 12 examination crushes in 1 large open sided shed. Low-stress stock handling principles were always adhered to when moving and handling cows. Prior to synchronization, TRP was performed by an experienced veterinarian to assess reproductive organs and to exclude any reproductive abnormalities. A modified controlled internal drug releasing device (CIDR)-OB synchronization protocol was used. Each cow had an Eazi-breed™ CIDR® (Zoetis) containing 1.38 grams of progesterone placed intravaginally (day 1). After 7 days, CIDRs were removed and 24 hours later (day 8) 1 ml of intramuscular Bomerol™ (estradiol benzoate, 1 mg/ml, Elanco) was given. The AI assessment took place 3 days later (day 11). After AI assessment, cows received 1 ml intramuscular Juramate® (prostaglandin, 250 µg/ml, Jurox).

Artificial insemination assessment

Seven days after AI training, both G_{fb} and G_0 cohorts attended a live cow AI assessment where the participants' ability to pass an AI pipette through the cervix and into the uterus of a non-pregnant cow was assessed. On the AI assessment day, 7 cows were brought into the crush facilities at a time. Prior to any student palpations, cows were palpated by an experienced veterinarian to determine estrous cycle stage allowing investigators to choose cows. Any cow not in estrus or proestrus was released and another cow was brought for assessment. This palpation also allowed emptying of feces prior to students' palpation. Students worked in pairs of 1 G_{fb} and 1 G_0 participant. There was 1 cow allocated to each pair of students. Each student had 10 minutes to attempt passing the AI pipette through the cervix. While 1 student was passing the AI pipette, their partner timed them and held the cow's tail out of the way. Roles were switched after pipette placement was checked by an experienced veterinarian and the second student attempted to pass the AI pipette. Pipette placement was evaluated transrectally by an experienced veterinarian and recorded as correct (tip of AI pipette felt in the uterine body) or incorrect (tip of AI pipette not felt in the uterine body). If there was any sign of mucosal bleeding during rectal palpations, students had to stop performing the procedure immediately, and the cow was removed from the project. The cow was examined by an experienced veterinarian and not used for any further palpations. The student was given a new cow to complete the assessment.

Data collection

Data collection was carried out using a hard copy paper sheet for the AI assessment and included: the name of the student, their student number, the ear tag number of the cow they used, which hand was used to rectally palpate, and whether they were successful in passing the AI pipette into the uterine body of the cow based on assessor feedback. 'YES' and 'NO' indicated if the student was successful or not in passing the AI pipette. Data collected on the cows included ear tag number, whether they were in estrus or proestrus, and whether they had mucosal bleeding or any other health concerns after student palpations. Data were then transferred to an electronic spreadsheet after AI assessment.

G_{fb} participant questionnaire

Participants in G_{fb} filled in a short anonymous hard copy questionnaire after completion of the AI assessment. The questions were aimed at getting feedback on the 8 weeks of FB practice and to better understand limitations of the study. Questionnaire data was then transferred into an electronic data sheet.

Data analysis

Chi Square test for independence was used to assess the relationship between pipette placement outcome and exposure (G_{fb} versus G_0) (https://epitools.ausvet.com.au/).

Ethical considerations

Animal ethics for this project was approved by the Animal Ethics Committee of Murdoch University (Protocol

Citation line: Clinical Theriogenology 2023, 15, 9595, http://dx.doi.org/10.58292/CT.v15.9595

R3353/21). Human ethics for this project was approved by the Human Ethics Committee of Murdoch University (Protocol 2021/146).

Results

Study population

A total of 28 students enrolled in this study. Seventeen students took part in G_{fb} and 11 in G_0. There were 21 female students and 7 male students across both groups that equals 75 and 25% of the study population, respectively. Of the 21 female students, 12 took part in G_{fb} and 9 in G_0. Five of the 7 male students were in G_{fb} and 2 were in G_0. The study cohort is representative of the class (n = 98 students) that has a gender distribution of 83 and 17% for female and male students, respectively.

Passing AI pipette

On AI assessment day, 6 participants from G_{fb} (6/17, 35%) and 2 participants from G_0 (2/11, 18%) were successful in passing the AI pipette into the body of the cow's uterus (Figure 2). The proportions of each group to be successful in passing the AI pipette were 0.35 and 0.18 for G_{fb} and G_0, respectively. Participants in G_{fb} demonstrated a higher proportion of successful pipette placements compared to G_0. Overall, there was no difference ($p = 0.58$) between students with TS practice compared to students without FB practice in their ability to pass an AI pipette into cow's uterus.

Questionnaire feedback

Of the 16 G_{fb} participants who completed the questionnaire, all said they had enjoyed playing FB for the 8 weeks. Two students indicated that they were able to play FB for the required time each week and 14 students indicated they were unable to complete the required playing time each week. Five of the 14 students were unable to complete the required playing time said that they did not make up the playing time during following weeks and 9 students indicated that they were able to make up playing time. Main reasons for students missing FB playing time were not being on campus enough and absence during the semester break. One participant mentioned that the number of FB tables was insufficient. Fifteen out of 16 respondents said they would keep playing FB for fun after completion of the project.

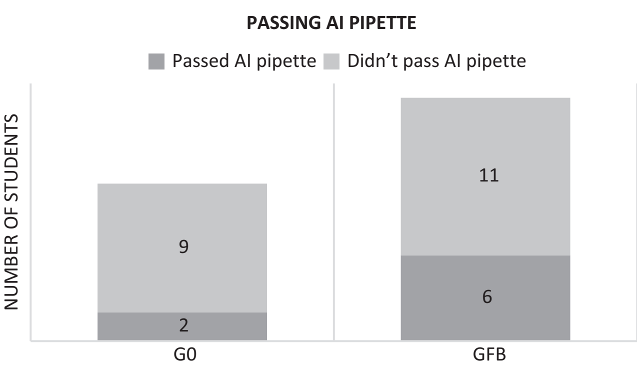

Figure 2. Number of successful and unsuccessful participants at passing AI pipette into cow's uterus for G_{fb} (6/17, 35% successful) and G_0 (2/11, 18% successful)

Estrus synchronization

Of the 25 synchronized cows, 16 were used for AI assessment. Of the 16 cows used on the assessment day, 15 were in estrus and 1 in proestrus. Three cows used for AI assessment had some mucosal bleeding noted after the second student palpation. These cows were examined by an experienced veterinarian before removal from examination crushes. There were 2 cows with mucosal bleeding after the first student palpation. These cows were removed from the project immediately after examination by the veterinarian and another cow was brought in for the second student assessment in each case.

Discussion

We aimed at identifying an alternative training approach to the skills required for bovine AI. It follows a recent trend in veterinary and nonveterinary education where alternative training methods have been utilized to improve acquisition of important clinical and nonclinical skills.[13,14,15] The main finding of this study was that the relationship between TS practice and veterinary students' ability to pass an AI pipette into the uterus of a cow was not different ($p > 0.05$). Although not significant, the proportion of successful students in G_{fb} (0.35) was more than that in G_0 (0.18). This suggested that TS practice may have had some effect on the student's ability to pass an AI pipette into the uterus of a cow. This study relied heavily on G_{fb} participant commitment and ability to play TS for the required amount of time each week to develop muscle memory, as this requires repeated practice of a specific motion.[19,20] Fourteen of the 16 G_{fb} participants who completed the questionnaire indicated that they were unable to play FB for the required time each week, which is expected to have negatively impacted muscle memory development. Nine of the 14 students were able to make up playing time when they missed a FB session; however, this inconsistency in FB playing could have also influenced muscle memory development. Lecture-free weeks were the main reason to miss FB sessions amongst G_{fb} participants. Some students indicated they missed FB practice for an entire 2 weeks. The 2-week break was difficult to avoid when planning the timeline for the project. However, if all students in G_{fb} had managed to consistently play FB for the required time each week it may have had an influence on the results.

The building of motor memory or the learning of a new motor skill generally has 2 phases, the first being acquisition of the skill and the second being consolidation through practice and repetition of the skill.[21] Long term recall of the skill depends on proper consolidation.[21] Although humans have the capacity to learn and retain many motor memories, forming motor memory for a skill can be interrupted by the learning of different motor skills.[22] The motor memory for a new skill is fragile immediately after practice, and if another skill is learnt shortly afterwards interference of the first skill may occur.[22] It is for this reason that motor memory development may not have been optimal during this project. Students are learning many different new motor skills throughout the veterinary course. Students may have gone from playing FB to a surgery skills class, which may have interrupted formation of the motor memory from FB practice and may have ultimately affected results. Furthermore, missing FB sessions is expected to have had an influence on the consolidation of the motor memory.

Transrectal palpation experience is another factor to consider. Although all participants were from the same year level and had a similar baseline level of TRP experience and training, it is not known if they had indeed basic palpation competence. Since TRP competence requires extensive training and live cow palpation practice,[23,24] it is possible that most students taking part in this study would not have been competent due to limited live cow training opportunities.[25] Although the AI process does not require TRP examination of the entire reproductive tract, it is essential to locate and be able to grasp the cervix. One student from G_{fb} commented on the questionnaire that lack of TRP training and competence made the live cow AI task difficult due to inability to locate the cervix and pick it up. Furthermore, live cow TRP can cause arm muscle fatigue in those not used to it as it requires a set of unique physical efforts.[14] This may have made the AI task more difficult for students. Therefore, a future approach to AI skills acquisition should ensure that participants do have the necessary TRP competence as could be evaluated by an objective TRP assessment.[26]

There may also be an emotional component to successfully perform bovine TRP and AI that may have influenced the results of this study. Veterinary students' empathy levels towards animals and views on animal welfare[27,28] could have caused concern among students around the amount of pressure or force that can safely be applied during TRP and AI without harming cows. Since this is something learned by experience and exposure to live cow training, participants' inexperience in TRP could have influenced their ability to pick up the cervix and carry out the AI task.

This study was designed so that the AI assessment set-up resembled real-life as closely as possible. The cattle used for AI assessment were synchronized and in estrus as would be expected in a real-life AI setting. Cattle were examined by an experienced veterinarian to ensure correct cycle stage before used for the AI assessment. By ensuring that cattle were in estrus, any extra difficulty in performing the procedure was removed. The cycle stage of the cows can therefore be excluded as a reason for students' inability to pass the AI pipette into the uterus.

One promising finding of this study came from the questionnaire in which students indicated that they had fun during the 8 weeks of FB practice. Fifteen out of the 16 respondents to the questionnaire also indicated that they would continue to play FB after completion of the study. This may have implications in helping to reduce stress amongst veterinary students. It is well known that veterinary education programs in Australia and overseas are challenging and demanding programs.[29,30] The work load is extensive and can cause students to feel chronically overwhelmed by constant pressure.[30] The stress experienced by students while studying veterinary medicine has been recognized to stem from factors like the large number of contact hours, and the pressure to pass high-stakes examinations, as well as financial pressures and less time for social activities.[31] Literature on coping with stress indicates that employing a range of stress management strategies is best.[32] Foosball is something that is easy to make available at veterinary schools and may help students break up busy study schedules and reduce stress by providing a source of fun.

A major limitation of this study was the small sample size and the uneven distribution of participants among the study cohorts. An ideal sample size was initially calculated based on a population size of 100 at a 95% confidence level and a confidence interval of 0.95, and would have been 80 participants in total, 40 per cohort. However, due to budget restrictions limiting the number of FB table purchases, cattle availability, and COVID-19 pandemic restrictions and constraints due to student availability, student numbers per cohort were adjusted to 24.

Due to difficulty in recruiting students to the project, the cohorts were much smaller than initially planned for with 17 and 11 participants in G_{fb} and G_0, respectively. The difficulty recruiting students to the project may have been due to the time commitment required to take part in FB practice as well as AI training and assessment. The 4th year of veterinary education at Murdoch University has a demanding class timetable and students may not have wanted to add other commitments to their schedule. Timing of the project also meant that AI training and assessment occurred during the final weeks of the trimester making it quite close to their final examinations, which may have also contributed to lack of student interest in the project. Students may have also lacked an interest in large animal veterinary practice, and therefore in a bovine AI project. Another shortfall of the study is that tracking of playing time for G_{fb} participants was not done. It would have added valuable data as consistency of playing FB could have been evaluated as a direct variable affecting participants' ability to pass a pipette through the cervix or not. It could have potentially also been used to assess if participants who took longer to pass the pipette were those who played less. This kind of evidence would have strengthened the findings and should be included in any similar future investigations.

Conclusion

Although results did not support our hypothesis, there were various factors, including, small cohort sizes and incomplete G_{fb} participant commitment to the required FB playing time that may have influenced the results unfavorably. Therefore, this result should not discourage veterinary educators from further investigating alternative teaching approaches to help improve the teaching and learning of important clinical skills at veterinary schools. Furthermore, this study highlights the importance of assessing competence for clinical skills that are required to learn new skills first (TRP in this case) before attempting to teach the new, more advanced skill (AI in this case). This is likely to be applicable for many other clinical skills.

Acknowledgement

Authors thank the staff at the Murdoch University veterinary farm for providing the cattle and facilities required to make this study possible. That gratitude also extends to the staff at the Production Animal Hospital at Murdoch University for their assistance in acquiring equipment and consumables, and the Murdoch Veterinary Students Association for providing the space for students to play FB.

Conflict of interest

Authors have no conflict of interest to report.

Authors' contributions

Mia Norton: Conceptualization, project execution and data collection, writing, review and editing.

Annett Annandale: Conceptualization, project execution and data collection, review and editing.

References

1. Dalton JC, Robinson JQ, Price WJ, et al: Artificial insemination of cattle: description and assessment of a training program for veterinary students. J Dairy Sci 2021;104:6295–6303. doi: 10.3168/jds.2020-19655
2. Vishwanath R: Artificial insemination: the state of the art. Theriogenology 2003;59:571–584. doi: 10.1016/S0093-691X(02)01241-4
3. Diskin MG: Review: semen handling, time of insemination and insemination technique in cattle. Animal 2018;12:s75–s84. doi: 10.1017/S1751731118000952
4. López-Gatius F: Factors of a noninfectious nature affecting fertility after artificial insemination in lactating dairy cows. A review. Theriogenology 2012;77:1029–1041. doi: 10.1016/j.theriogenology.2011.10.014
5. Barth AD: Factors affecting fertility with artificial insemination. Vet Clin North Am Food Anim Pract 1993;9:275–289. doi: 10.1016/S0749-0720(15)30646-0
6. Rösch T, Schaper E, Tipold A, et al: Clinical skills of veterinary students – a cross-sectional study of the self-concept and exposure to skills training in Hannover, Germany. BMC Vet Res 2014;10:969. doi: 10.1186/s12917-014-0302-8
7. Dilly M, Read EK, Baillie S: A survey of established veterinary clinical skills laboratories from Europe and North America: present practices and recent developments. J Vet Med Educ 2017;44:580–589. doi: 10.3138/jvme.0216-030R1
8. Kneebone R, Baillie S: Contextualized simulation and procedural skills: a view from medical education. J Vet Med Educ 2008;35:595–598. doi: 10.3138/jvme.35.4.595
9. Ericsson KA, Charness N: Expert performance: its structure and acquisition. Am Psychol 1994;49:725–747. doi: 10.1037/0003-066X.49.8.725
10. Smeak DD: Teaching surgery to the veterinary novice: the Ohio State University Experience. J Vet Med Educ 2007;34:620–627. doi: 10.3138/jvme.34.5.620
11. George J, Doto F: A simple five-step method for teaching clinical skills. Fam Med 2001;33:577–578.
12. Annandale A: Thinking differently about clinical skills training: the bovine pregnancy diagnosis via transrectal palpation showcase. Utrecht, The Netherlands University: 2020.
13. Fernandez NJ, Fischer M, Burgess H, et al: Using fine arts-based training to develop observational skills in veterinary students learning cytology: a pilot study. J Vet Med Educ 2021;48:295–300.
14. Annandale A, Fosgate GT, Eksteen CA, et al: Influence of an exercise program, muscle strength, proprioception, and arm length on veterinary students' bovine pregnancy diagnosis accuracy. J Vet Med Educ 2021;48:196–210. doi: 10.3138/jvme.2019-0043
15. Hugo AJ, Horn CA: Using music activities to enhance the listening skills and language skills of Grade 1, English first additional language learners. Per Linguam 2013;29(1):63–74. doi: 10.5785/29-1-542
16. Hopper RM: Bovine reproduction. Hoboken NJ; John Wiley & Sons, Incorporated: 2014.
17. Gundersen K: Muscle memory and a new cellular model for muscle atrophy and hypertrophy. J Expt Biol 2016;219:235–242. doi: 10.1242/jeb.124495
18. Krakauer JW, Shadmehr R: Consolidation of motor memory. Trends Neurosci 2006;29:58–64. doi: 10.1016/j.tins.2005.10.003
19. Pinzon D, Vega R, Sanchez YP, et al: Skill learning from kinesthetic feedback. Am J Surg 2017;214:721–725. doi: 10.1016/j.amjsurg.2016.10.018
20. Diekelmann S, Born J: One memory, two ways to consolidate? Nat Neurosci 2007;9:1085–1086. doi: 10.1038/nn0907-1085
21. Thomas R, Flindtgaard M, Skriver K, et al: Acute exercise and motor memory consolidation: does exercise type play a role? Scand J Med Sci Sports 2017;27:1523–1532. doi: 10.1111/sms.12791
22. Lundbye-Jensen J, Petersen TH, Rothwell JC, et al: Interference in ballistic motor learning: specificity and role of sensory error signals. PLoS One 2011;6:e17451. doi: 10.1371/journal.pone.0017451
23. Bossaert P, Leterme L, Caluwaerts T, et al: Teaching transrectal palpation of the internal genital organs in cattle. J Vet Med Educ 2009;36:451–460. doi: 10.3138/jvme.36.4.451
24. French HM, Dascanio JJ, Gilbert GE, et al: Bovine reproductive palpation training: does the cow make a difference? J Vet Med Educ 2018;45:219–223. doi: 10.3138/jvme.1116-172r
25. Lopes G, Rocha A: Teaching bovine rectal palpation with live cows in the slaughterhouse: is it worthwhile? Reprod Domest Anim 2006;41:510–513. doi: 10.1111/j.1439-0531.2006.00705.x
26. Annandale A, Fosgate GT, Bok H, et al: Ability of a bovine transrectal palpation objective structured clinical examination to predict veterinary students' pregnancy diagnosis accuracy. Vet Rec 2019;185:171. doi: 10.1136/vr.105022
27. Paul ES, Podberscek AL: Veterinary education and students' attitudes towards animal welfare. Vet Rec 2000;146:269–272. doi: 10.1136/vr.146.10.269
28. Pirrone F, Mariti C, Gazzano A, et al: Attitudes toward animals and their welfare among Italian veterinary students. Vet Sci 2019;6:19. doi: 10.3390/vetsci6010019
29. McLennan MW, Sutton RH: Stress in veterinary science students: a study at the university of Queensland. J Vet Med Educ 2005;32:213–218. doi: 10.3138/jvme.32.2.213
30. Collins H, Foote D: Managing stress in veterinary students. J Vet Med Educ 2005;32:170–172. doi: 10.3138/jvme.32.2.170
31. Lokhee S, Hogg R: Depression, stress and self-stigma towards seeking psychological help in veterinary students. Aust Vet J 2021;99:309–317. doi: 10.1111/avj.13070
32. Williams SM, Arnold PK, Mills JN: Coping with stress: a survey of Murdoch university veterinary students. J Vet Med Educ 2005;32:201–212. doi: 10.3138/jvme.32.2.201