Effect of a high-intensity one-week training programme and student-level variables on the bovine transrectal palpation and pregnancy diagnosis skills of final-year veterinary students

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Abstract

Background To improve bovine transrectal palpation (TRP) and pregnancy diagnosis (PD) training, the effect of a high-intensity one-week training programme for veterinary elective students (N=59) with an interest in production animal practice was evaluated.

Methods Training consisted of exposure to rectal examination simulators, abattoir organs, theory materials and live cow PDs supervised by experienced large animal practitioners. Palpation skills were assessed before and after training using a validated TRP Objective Structured Clinical Examination (OSCE) in non-pregnant cows. Each student then performed PDs (n=12) on cows of known pregnancy status. Students' PD accuracy was measured as sensitivity and specificity, being respectively defined as the proportion of pregnant and non-pregnant cows correctly identified.

Results Students' scores improved from the first to the second OSCE (P=0.03), mostly as a result of improved ability to identify uterine symmetry/asymmetry and the presence/absence of a corpus luteum on the right ovary (P<0.01 and P=0.03, respectively). Overall student sensitivity and specificity of PD were 89.1 per cent (95 per cent CI 78.1–92.2 per cent) and 67.7 per cent (95 per cent CI 60.1–74.5 per cent), respectively.

Conclusion This prospective cohort study describes a strategy to improve students' TRP skills with the potential to reduce training time and animal use at teaching institutions by outsourcing student training to private practitioners.

Introduction

Bovine transrectal palpation (TRP) and pregnancy diagnosis (PD) are complex skills that require extensive training and exposure to TRP in live cows.[1–3] Transrectal palpation and PD are economically important[4–7] and frequently performed procedures in bovine practice,[8] and are therefore important skills for veterinary graduates.[9] Student training is challenging due to limited teaching animal availability, welfare concerns and the costs associated with farm visits for student training purposes. Furthermore, student training opportunities for bovine TRP and PD are not easily accessible outside the veterinary course.[3 10 11] It has recently been shown that the overall PD accuracy (pregnancy status and stage) of fourth-year and fifth-year students (of a six-year course) was lower than what is considered acceptable for large animal veterinarians.[3 11–16] Overall PD accuracy via TRP in cows more than 35 days pregnant has been reported as high as 99.7 per cent for experienced large animal practitioners, with a sensitivity of 100 per cent and a specificity of 99.4 per cent.[13] Students' PD specificity (ability to correctly identify non-pregnant cows) was lower than sensitivity

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(ability to correctly identify pregnant cows), and the majority of students had insufficient palpation skills after TRP and PD training.[3 11 16] In an effort to overcome training constraints due to limited live cow access and to improve bovine TRP training, several studies have investigated various training methods,[3 10 17] rectal examination simulator use,[1 3 11 16 18–20] and factors influencing students' TRP and PD performance.[2 3 11 16] While rectal examination simulator training was shown to be superior to theoretical instruction only,[18 21] live cow training resulted in better student TRP skills and PD accuracy for cows less than six months pregnant.[1 3] It is recommended to combine rectal examination simulator training with live cow palpations to optimise learning outcomes.[1 3 11 16] Providing additional rectal examination simulator and live cow training sessions for a fifth-year student cohort was not sufficient to reach an overall competent student palpation level.[16] Implementation of live cow palpation access, limited to students interested in a career in food animal practice during the later stages of the curriculum, was proposed as an approach to improve students' palpation abilities.[16] This approach and the effect on students' TRP and PD skills have not been investigated yet. A TRP Objective Structured Clinical Examination (OSCE) has the ability to predict students' PD accuracy.[16] The described TRP OSCE used nine individual items to evaluate students' palpation skills (size and position of the cervix; size, tone and symmetry of uterine horns; ovary size and presence of pertinent structures on the ovaries). Scores for correctly describing/identifying individual OSCE items were ordinally transformed and used to allocate students into palpation skills categories: no palpation skills (0–1 out of 9), deficient palpation skills (2 or 3 out of 9), some palpation skills (4 or 5 out of 9), good palpation skills (6 or 7 out of 9) and competent in palpation (8 or 9 out of 9), as described previously.[16] Student categorisation into having 'competent palpation skills' was associated with higher PD specificity.[16] The TRP OSCE was a valid assessment with good reliability for all items within the station (with a test score reliability Cronbach's alpha coefficient of 0.78).[16 22 23] The described TRP OSCE could be used to track students' progress during or after TRP and PD training sessions.

Other factors that have been shown to influence students' PD accuracy have been described.[3 11] These factors included previous bovine TRP and PD experience, gender and grip strength. Since previous investigations have involved fourth-year and fifth-year veterinary student cohorts (of a six-year course),[24] the effect of these factors on a final-year student cohort was regarded worth evaluating. While a grip strength of more than 30 kg has previously been associated with a higher student ability to identify pregnant cows,[11] the effect of grip strength on live cow TRP OSCE results has not yet been reported. Veterinary students follow the general population trend where approximately 90 per cent of people are right-handed.[11 25] Due to on-farm examination crush set-up, it is often not possible to choose which arm to use for bovine PDs in South Africa, and there are no student data on arm preference for bovine TRPs available. Being able to use the preferred arm for bovine TRP might have an effect on palpation accuracy, but has not yet been investigated.

The main aim of the study was to evaluate the effect of a one-week intense training programme on bovine TRP skills of final-year (of a six-year programme) veterinary students interested in production animal practice as assessed via TRP OSCE, and if this approach could potentially reduce training time and teaching animal use at teaching institutions by outsourcing student training to private practitioners with access to real patients.

The study also evaluated if post-training TRP OSCE scores were predictors of student PD accuracy. Furthermore, the study evaluated if previous bovine TRP experience, number of PDs performed during the training programme, grip strength and being able to use the preferred arm for TRPs were predictors of TRP OSCE and PD accuracy results.

It was hypothesised that a one-week intense training programme was an appropriate strategy to improve students' TRP OSCE scores and palpation abilities and furthermore could overcome training limitations at teaching institutions. It was additionally hypothesised that TRP OSCE scores were predictive of PD accuracy.

Materials and methods

Participants and setting

Participants in this prospective cohort study were final-year (of a six-year programme)[24] veterinary students (N=59) at the Faculty of Veterinary Science, University of Pretoria, South Africa. The six-year Bachelor of Veterinary Science (BVSc) programme includes nine semesters of didactic preclinical training and three semesters of clinical work-integrated learning during the last 18 months of study.[24]

Only students who chose electives indicative of an interest in large animal practice during the last three semesters of clinical work-integrated learning were able to enrol for the one-week intense bovine PD training ('The Onderstepoort PD Challenge'). The training programme took place in July 2018 after students had completed the first two semesters of clinical work integration.

Student TRP and PD training before the experiment

During the fourth year of didactic training, theoretical and practical aspects of bovine TRP and PD are taught within the veterinary reproduction module.[24] This includes hands-on training on reproductive tract abattoir organs, rectal examination simulators and live cows, as previously described.[3 16] Students are furthermore exposed to additional bovine TRP opportunities later

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in the curriculum within the mandatory reproduction and/or herd health clinical rotations during the first two semesters of clinical work integration at the teaching institution, and optionally during private practice rotations.

Pretraining and post-training assessment of students' TRP skills

All participants' pretraining and post-training TRP skills were assessed by means of a TRP OSCE on non-pregnant cows with no reproductive tract pathology.[16] The TRP findings for each cow were predetermined (by TRP and ultrasound examination) and documented by two experienced specialist veterinarians. The veterinarians' diagnoses were used as a reference to determine students' OSCE scores. The pretraining TRP OSCE was done at the beginning of the one-week training programme before any additional training. The post-training TRP OSCE was done exactly one week later after completion of the intense TRP and PD training. During both OSCE assessments, each student palpated one live cow and wrote down their findings on an OSCE marking sheet.[16] Before the pretraining TRP OSCE, student information on dominant hand and the preferred arm for TRPs was documented. Students could choose which arm they preferred to use and were instructed to use the same arm for both OSCEs. Examination time was restricted to 10 minutes per student. The nine scores used to evaluate palpation skills (size and position of the cervix; size, tone and symmetry of uterine horns; size and presence of pertinent structures on the ovaries) were ordinally transformed as described previously.[16]

Grip strength measurement

Before the pretraining TRP OSCE, grip strength was measured in kilograms using the handheld digital CAMRY Model EH 101 Grip Strength Dynamometer (CAMRY Scale USA, South El Monte, California) according to the manufacturer's instructions. Students were asked to squeeze the hand grip with maximal effort for three to five seconds. Right and left hand grip strength were measured and recorded.[11]

TRP and PD training at the teaching institution

The day following the pretraining OSCE assessment, all 59 final-year veterinary students received a mandatory day of additional bovine TRP and PD training at the teaching institution, supervised and executed by experienced faculty members. The training included inspection and palpation of abattoir specimens of bovine female reproductive organs, skills laboratory exposure to rectal examination simulators (Breed'nBetsy (BB) and Haptic Cow) and exposure to theoretical information on bovine TRP and PD for self-study. Students (N=59) were randomly divided into six groups of 9–10 students and each group rotated through all training stations. Two groups were at one of the three training stations simultaneously, and two-hour training periods were allocated to each station. The abattoir specimens included non-pregnant uteri as well as uteri at various stages of gestation. Separate BB simulators were set up using non-pregnant uteri and a variety of pregnant uteri models of 6–11 weeks and 4–5 months of gestation.[3] The Haptic Cow training allowed students to palpate non-pregnant uteri and a range of pregnancy stages: 7–7.5 weeks, 8–8.5 weeks, 4–5 months and 6–7 months.

Private practice placements

Students then spent two days at private practices performing bovine PDs under the supervision of experienced veterinarians. Private practitioners were asked to participate in the project via a call on a national rural practitioners email list serve ('Ruralvet'). A total of 24 practices volunteered to participate and accommodated all students. One to seven students were allocated per practice (median: two students). Students received a travel allowance to cover the costs associated with the private practice placements.

PD accuracy assessment

Students' bovine PD accuracy via TRP was assessed as described previously.[3 16] All students (N=59) visited a commercial Nguni beef cattle herd one day (student groups 1, 2 and 3) or two days (student groups 4, 5 and 6) after the second TRP OSCE assessment. Each student completed a questionnaire on previous bovine TRP and PD experience.[3] The questionnaire also contained questions concerning the one-week training programme. Each student was then allowed a total of 15 minutes to perform PDs via TRP on 12 cows. The pregnancy status and stage of these cows were determined by a veterinarian via TRP with more than ten years' experience in bovine TRP and PD. The veterinarian's diagnosis was used as the reference for student diagnosis. For cows less than six months pregnant, a student's stage of pregnancy estimation was considered to be correct if it was within one month of the finding of the experienced veterinarian, and in the case of cows more than six months pregnant if the student's finding was within two months of the veterinarian's finding. Due to the examination crush set-up on the farm, all student palpations were performed left-handed. Each student's PDs (pregnancy status and stage) were recorded on an individual data capture sheet against the unique cow identification number, and students who examined the same cow were blinded to each other's diagnoses.[3 16] Cows were not formally randomised but taken into the crush in a convenient manner out of a group of available cows.

Statistical analysis

Quantitative data were assessed for normality by evaluating histograms, calculating descriptive statistics

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and performing the Anderson-Darling test using commercial software (Minitab Statistical Software, Release 13.32, Minitab, State College, Pennsylvania, USA). Quantitative data that violated the normality assumption were analysed using non-parametric procedures. Quantitative data were compared between levels of categorical predictors using Mann-Whitney U or Kruskal-Wallis tests for variables with two and three levels, respectively. Paired quantitative data were compared using Wilcoxon signed-rank tests. Bivariate correlation between quantitative variables was estimated using Spearman's rho. Paired dichotomous data were compared using McNemar's chi-squared tests.

Statistical analysis of factors affecting PD accuracy

Sensitivity was defined as the proportion of cows determined to be pregnant by the veterinarian that were correctly identified by the student. Stage-corrected sensitivity was defined as the proportion of pregnant cows in which pregnancy stage was correctly identified by the student. Specificity was defined as the proportion of non-pregnant cows as determined by the veterinarian correctly identified by the student. Overall accuracy was calculated as the proportion of cows in which the student determination of pregnancy was the same as the veterinarian's. Sensitivity is the probability that the student correctly recognised a pregnancy, and therefore factors associated with the sensitivity of student PD were evaluated only within cows that were determined as pregnant by the veterinarian. A generalised linear model approach was used with the outcome being the dichotomous diagnosis (pregnant/non-pregnant) of the student. Random effect terms were included in these models for student and cow to account for the study design in which a single student examined multiple cows and each cow was examined by multiple students. The effects of student factors on the PD were evaluated by screening each possible predictor one-by-one in univariate analyses that included these variables as fixed effects in the model. All variables in which P<0.20 in these screening models were subsequently evaluated using a multivariable approach that included all variables identified in the screening models. Multivariable models were fit using a manual backwards stepwise procedure. Variables were removed from the multivariable model when the statistical test of the variable's coefficient was P>0.05. The variable with the largest P value was removed first and the model was rerun again. The removal of variables continued until all remaining factors were P<0.05. Confounding was assessed by calculating the per cent change in the odds ratio for the treatment group variable (primary exposure of interest) between the model with the factor and the model after factor removal. If removal of a variable caused a greater than 20 per cent change in the odds ratio of another variable, then the variable was classified as an important confounder and added back into the multivariable model. Models evaluating the factors associated with student specificity were fit using the same procedures as described for sensitivity but within the subset of cows identified as non-pregnant by the veterinarian. Commercial software was used for all statistical analyses (IBM SPSS Statistics V.24, International Business Machines, Armonk, New York, USA) and significance was set as P<0.05.

Results

Study participants

The study population consisted of 59 final-year veterinary students, of whom 33 were female and 26 were male (56 per cent and 44 per cent, respectively).

Of the 59 students, 41 had chosen rural veterinary practice and wildlife and 18 intensive animal production as their Veterinary Elective Programme.

Of the 59 students, 56 (97 per cent) were right-handed and 2 (3 per cent) were left-handed. One student indicated equal preference for left and right hand. Of the students, 46 (78 per cent) and 13 (22 per cent) indicated their preferred hand for TRPs was left and right, respectively.

Right hand grip strength ranged from 22.2 kg to 75.6 kg (mean: 46.6±15.6 kg), with a significant gender difference (mean 34.6 kg and 61.5 kg for female and male students, respectively; P<0.001). Left hand grip strength was lower than the right hand (P<0.001), and ranged from 22.4 kg to 76 kg (mean: 43.2±14.5 kg), and also differed by gender (mean 32.6 kg and 56.4 kg for female and male students, respectively; P<0.001).

One student was sick on the day of the PD assessment and did not participate. The same student also did not complete the questionnaire. Analysis of completed questionnaires (n=58) showed that 15 students (26 per cent) indicated that their bovine TRP experience was limited to what they had been exposed to during the formal training at the teaching institution. Of the 58 students, 37 (64 per cent) and 6 (10 per cent) had additional TRP exposure outside the veterinary course with and without supervision of a veterinarian, respectively. Students' palpation experience before and during the one-week training programme is summarised in table 1. The average number of PDs performed by students during private practice placements within the one-week training programme was 159 (median 110, min 20, max 600; table 1).

Comparison of pretraining and post-training live cow TRP OSCE results

Total live cow TRP OSCE scores were significantly higher for the second post-training OSCE (P=0.03). Individual OSCE components that students were more likely to correctly identify post-training compared with pretraining were uterine symmetry/asymmetry (P<0.001) and presence/absence of a corpus luteum on

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Table 1 Pregnancy diagnosis (PD) experience by 58 final-year veterinary students before and during the training programme						
Number of PD performed before the one-week training programme						
	<50	50–100	100–200	200–500	500–700	1000–1500
Number of students	13 (22%)	23 (40%)	9 (16%)	3 (5%)	2 (3%)	8 (14%)
Number of PD performed during the one-week training programme						
	<50	50–100	100–200	200–500	500–700	1000–1500
Number of students	5 (9%)	24 (41%)	15 (26%)	12 (21%)	2 (3%)	0

the right ovary (P=0.030). Post-training OSCE scores improved for 7 of 7, 16 of 19 and 19 of 30 students with deficient, some and good initial TRP skills, respectively (figure 1). Student distribution within the different palpation skills categories for the pretraining and post-training TRP OSCE is summarised in figure 1.

Correlation between pretraining total TRP OSCE scores and gender, previous palpation experience and grip strength

The median total pretraining TRP OSCE scores were significantly higher for male students (P=0.039). Grip strength of the preferred hand was positively correlated with the total TRP OSCE score at the initial pretraining assessment (Spearman's rho=0.400, P=0.002). Students' pretraining TRP OSCE scores did not vary by previous experience (P=0.223).

Correlation between post-training total TRP OSCE scores and gender, previous palpation experience, number of live cow PDs done during the one-week training and grip strength

Total TRP OSCE scores for the post-training assessment did not vary by gender (P=0.520) or previous palpation experience (P=0.243). Also, total post-training TRP OSCE scores were not significantly correlated to the number of live cows palpated during the training (P=0.486) or grip strength (P=0.641).

PD assessment, accuracy, sensitivity and specificity results

On the day of the PD assessment, 697 student palpations were performed, of which 444 (64 per cent) were on pregnant cows. Of these, 305 (69 per cent) were on cows less than six months pregnant and 139 (31 per cent) on cows more than six months pregnant. Of the 305 palpations on cows less than six months pregnant, 110 were on cows one-and-a-half to three months pregnant and 195 were on cows more than three to five months pregnant. Fifty-eight students each palpated 12 cows in the 15-minute time limit. Compared with the diagnoses provided by the experienced veterinarian, the mean overall student accuracy of PD was 81.6 per cent (95 per cent CI 77.7–84.9 per cent) for pregnancy status alone and 43.3 per cent (95 per cent CI 38.4–48.3 per cent) for pregnancy status with correct stage. The mean sensitivity (correctly identify pregnant cows) was 89.1 per cent (95 per cent CI 78.1–92.2 per cent). Student sensitivity for cows less than six and at least six months pregnant was 86.4 per cent (95 per cent CI 80.9–90.5 per cent) and 92.1 per cent (95 per cent CI 86.4–95.5 per cent), respectively. Stage-corrected mean sensitivity was 30.0 per cent (95 per cent CI 25.4–35.1 per cent). The mean specificity (correctly identify non-pregnant cows) was 67.7 per cent (95 per cent CI 60.1–74.5 per cent).

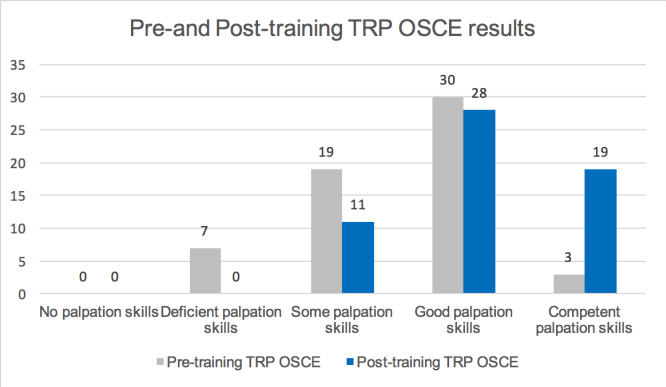

Figure 1 Schematic display of student allocation into palpation skills categories based on pretraining and post-training TRP OSCE scores of final-year veterinary students (N=59). OSCE, Objective Structured Clinical Examination; TRP, transrectal palpation.

Correlation between PD accuracy and grip strength

Higher grip strength (>35 kg) was associated with higher student PD sensitivity (P=0.011; table 2). Students with a grip strength of greater than 35 kg were 2.5 times more likely to identify pregnant cows correctly. Grip strength was not associated with PD specificity.

Associations between student-level variables and PD sensitivity

Within the univariate analysis that investigated each variable independently, none of the student-level variables (previous experience, number of PDs done during the one-week training programme and use of the preferred hand for TRPs during the PD assessment) was a significant predictor of students' PD sensitivity (table 2).

Associations between student-level variables and PD specificity

Within the univariate analysis, male students (P=0.025) and students who had previous TRP experience with a veterinarian (P=0.043) were more likely to correctly identify non-pregnant cows (ie, had higher PD specificity). The number of PDs performed during the one-week training programme was not associated with student PD specificity.

Within the multivariable analysis adjusted for other factors, male students were two times more likely to

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Table 2 Univariate associations between student-level variables and pregnancy diagnosis sensitivity for 58 final-year veterinary students in South Africa

Variable	Level	Parameter estimate ($\hat{\beta}$)	Odds ratio (95% CI)	P value
Gender	Male	0.668	1.95 (0.92–4.12)	0.080
	Female	Referent		
Previous experience	None	Referent		
	With non-veterinarian	−0.290	0.75 (0.20–2.84)	0.669
	With veterinarian	−0.219	0.80 (0.34–1.89)	0.614
Additional PDs	Yes	−0.091	0.91 (0.44–1.89)	0.805
	No	Referent		
Grip strength	<34.5	Referent		
	34.5–49.5	1.154	3.17 (1.39–7.25)	**0.006**
	≥50	0.792	2.21 (0.97–5.02)	0.059
Grip strength	≤35	Referent		
	>35	0.907	2.48 (1.23–4.97)	**0.011**
Number of PD*	<100	Referent		
	≥100	0.274	1.32 (0.64–2.70)	0.453
Preferred hand	Left	−0.299	0.74 (0.30–1.84)	0.518
	Right	Referent		

P values in bold indicate a significant difference.
*Number of live cow PDs done during the one-week training programme.
PD, pregnancy diagnosis.

correctly identify a non-pregnant cow compared with female students.

Associations between post-training TRP OSCE scores and PD sensitivity

Within the univariate analysis, students' ability to correctly estimate left uterine horn diameter and to correctly diagnose presence or absence of a corpus luteum on the right ovary was associated with higher student PD sensitivity (P=0.022 and P=0.017, respectively) (table 3). None of the other individual OSCE items was a predictor of students' PD sensitivity.

The multivariable analysis investigates that combined effects of multiple variables showed that students who correctly estimated left uterine horn diameter were 2.6 times more likely to correctly identify a pregnant cow compared with students who did not correctly estimate left uterine horn diameter. Furthermore, students who correctly diagnosed the presence or absence of a corpus luteum on the right ovary were 1.6 times more likely to correctly identify a pregnant cow compared with students who did not.

Table 3 Univariate associations between student post-training TRP OSCE scores and pregnancy diagnosis sensitivity for 58 final-year veterinary students in South Africa

Variable	Parameter estimate ($\hat{\beta}$)	Odds ratio (95% CI)	P value
Left horn diameter	0.838	2.31 (1.13–4.73)	**0.022**
Right horn diameter	0.331	1.39 (0.63–3.07)	0.410
Cervix diameter	0.383	1.47 (0.69–3.14)	0.322
Uterine symmetry	0.345	1.41 (0.67–2.99)	0.367
Intrauterine fluid	−0.046	0.96 (0.44–2.09)	0.908
Left ovary size	0.172	1.19 (0.55–2.58)	0.663
Right ovary size	−0.017	0.98 (0.47–2.08)	0.964
Corpus luteum left	−0.064	0.94 (0.43–2.06)	0.873
Corpus luteum right	−1.102	0.33 (0.13–0.82)	**0.017**
Follicle left	−0.325	0.72 (0.35–1.48)	0.375
Follicle right	0.188	1.21 (0.58–2.50)	0.611
Total*	0.051	1.05 (0.88–1.27)	0.583

P values in bold indicate a significant difference.
*Sum of the 11 individual assessment components and modelled as a continuous predictor.
OSCE, Objective Structured Clinical Examination; TRP, transrectal palpation.

Associations between post-training TRP OSCE scores and PD specificity

None of the individual OSCE items or overall OSCE score was associated with student PD specificity.

Student feedback on the one-week intense TRP and PD training programme

The response rate to feedback on the one-week training programme was 95 per cent (56 of 59). Of the students, 91 per cent (51 of 56) either agreed or strongly agreed that they enjoyed the one-week training programme and 80 per cent (45 of 56) agreed that the programme should be implemented as an annual event within the VEP workplace-based student training. Of the students, 60 per cent (33 of 55) indicated that the one-week training programme increased their interest in production animal practice.

Of the students, 77 per cent (43 of 56) and 18 per cent (10 of 56) strongly agreed or agreed that the live cow PD exposure in private practice was beneficial. Student feedback on the skills laboratory (rectal examination simulator exposure) and abattoir-obtained reproductive organ training suggested that students found the latter more beneficial.

Discussion

The significantly higher post-training TRP OSCE scores (P=0.030) indicate the value of a one-week, high-intensity bovine TRP training programme. Post-training OSCE scores improved for students with deficient, some and good initial TRP skills, respectively (figure 1), and the number of students in the competent palpation skills category increased from 3 to 19. Based on the post-training OSCE, 47 of 59 (80 per cent) students were now in the 'good or competent palpation skills' category, showing that the majority of students had developed sufficient palpation skills during the one-week training period.

Students' overall PD accuracy (82 per cent), sensitivity (88 per cent) and especially specificity (67 per cent) in this study were higher than previously reported for fourth-year and fifth-year veterinary students.[3 11 16] This finding supports the approach to implement focused live cow TRP and PD training during the later stages of the curriculum for selected students with an interest in food animal practice.[16] Focusing on non-pregnant cow palpations and specificity was highlighted as an area of TRP and PD training improvement.[3] A student specificity of 67 per cent means that two out of three cows were correctly identified as non-pregnant by the students in this study, while it would have only

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been one out of three cows previously (41 per cent[3] and 42 per cent[16]). Since the ability to identify non-pregnant cows has direct financial implications for the farmer,[14 26 27] the higher student specificity in this study is an important and valuable finding. Stage-corrected sensitivity (defined as the proportion of pregnant cows in which pregnancy stage was correctly identified by the student) is similarly low as previously reported (31 per cent).[16] The authors acknowledge that even experienced veterinarians might find it difficult to correctly estimate gestation length beyond three months of pregnancy. However, the one to two months' 'allowance' for the students' findings based on the determined gestation length by the veterinarian (as described in the Materials and methods section) gave students a wide margin of error for pregnancy stage identification. These findings show that it is an area that requires further improvement and additional student training.

The individual post-training OSCE components associated with higher student sensitivity were students' ability to correctly estimate left uterine horn diameter and to correctly diagnose the presence or absence of a corpus luteum on the right ovary, both of which improved post-training. Students were more likely to correctly identify uterine symmetry/asymmetry ($P<0.001$) and presence/absence of a corpus luteum on the right ovary ($P=0.03$) post-training. The reason for the correlation between students' ability to correctly identify structures on the right but not on the left ovary is unclear. These OSCE components are considered more advanced TRP skills.[16] Correctly diagnosing structures on the ovaries requires students to be able to follow the uterine horns to find the ovaries, stabilise them and feel for ovarian structures. This skill is more advanced than locating the cervix and the uterus,[16] and therefore supports the positive association shown to PD accuracy. The same holds true for students' ability to correctly estimate uterine horn diameter, which would enable them to recognise uterine asymmetry as one of the important signs of pregnancy. An association between PD accuracy and a student's ability to give quantitative measurements is in accordance with a previous study where higher student PD sensitivity was shown to be associated with students' ability to correctly estimate ovary dimensions.[16] None of the more subjective measures, such as tone of the uterus, was a predictor of PD accuracy. These findings could be used to modify the OSCE components and concentrate exclusively on objective measures. The fact that the global OSCE score and a student categorisation into 'competent palpations skills' were not related to students' PD accuracy in this study stands in contrast to previously published findings where a student categorisation into 'competent palpation skills' was correlated to better student specificity of PD.[16] This could be due to the fact that at the time of PD assessment in this study the majority of students (80 per cent) had sufficient palpation skills, while only 11 per cent of students in the previous study were categorised as 'competent in palpation' and the majority of students had insufficient palpation skills. The poor correlation between global OSCE scores and PD performance in this study could also indicate that it might be beneficial to include other/more advanced OSCE criteria such as cycle stage determination as a diagnostic conclusion. A previous report on student TRP training showed that even though students were able to locate the cervix, uterus and ovaries during bovine TRPs, they had difficulty in interpreting these findings.[1] However, clinical interpretations of individual OSCE items might be beneficial for clinically advanced students. A practical recommendation from these findings would be to concentrate on more advanced TRP skills (ability to give quantitative measurements of reproductive structures and to correctly identify ovarian structures) during the initial TRP training before advancing to live cow PDs and to include OSCE criteria that require interpretation of clinical findings for more advanced students. Furthermore, revision of individual OSCE items based on evidence is proposed.

There was a high variation in the number of live cow palpations performed by students (range 20–600) during the private practice placements within the one-week training programme, with half of the students palpating fewer than 100 cows in total (table 1). Despite a previously reported positive correlation between the number of cows palpated and students' TRP skills,[1] in this study, there was no correlation between the number of cows palpated during the private practice placements and post-training OSCE scores, student PD sensitivity or specificity. This might be explained through the concept of 'deliberate practice',[28] which refers to 'intense, repetitive performance with specific, informative feedback and ongoing practice'.[28–30] The effect of deliberate practice on expert status in many professional disciplines, including chess, athletics, music and medicine, has been shown,[28 31] and its importance for veterinary education has been highlighted.[29 32] Therefore, it may well be that the level of supervision and feedback provided by specific veterinarians is more important than the overall number of cows palpated. The effect of private practice could not be statistically evaluated in this study as there were too many practices (n=24) and a median of two students per practice. However, feedback from students indicated that in practices where students palpated more than 300 cows during the two-day practice placements, there was often little feedback or supervision from the veterinarian due to time pressure. Other students highlighted the time and effort individual veterinarians took to teach them even though fewer cows were palpated. This reasoning could be further substantiated by the fact that only previous TRP experience with a veterinarian was associated with a higher student PD specificity, highlighting the effect of expert supervision. A practical application

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of this finding would be to identify veterinarians with an interest in student TRP training who are able to set aside time for sufficient feedback and supervision.

The fact that gender and grip strength were associated with higher pretraining but not post-training TRP OSCE scores might be explained by a previous finding where higher palpation accuracy for male students was thought to be linked to grip strength.[11] Grip strength is generally higher for men compared with women in the general population.[25] The same has been shown in this study and in a recently published study where male students' grip strength was higher than that of female students.[11] It is possible that a higher grip strength led to better gender performance in the pretraining OSCE in this study. However, palpation experience gained during the one-week training programme appeared to overcome the initial grip strength advantage of male students. The live cow palpation experience gained could have led to easier and faster reproductive tract finding and palpation. More efficient and competent palpation execution and technique might require less muscle activation and therefore less grip strength during palpations. The hypothesis that increased live cow palpation experience leads to decreased effort during non-pregnant cow palpations is supported by the associations of grip strength and PD sensitivity and specificity identified in this study. While grip strength was associated with students' PD specificity in a previous study,[11] this was not the case in this study. The cohort in the previous study were fifth-year students (of a six-year programme) as compared with final-year students in this study. The lower palpation experience level might therefore have required greater effort to correctly identify non-pregnant cows. Grip strength in this study was correlated with PD sensitivity, while there was no association in the previous study. One possible explanation is that while in general it seems easier for students to correctly identify pregnant compared with non-pregnant cows,[3 16] the fact that students palpated 12 cows instead of six as described previously could have influenced muscle fatigue and required endurance, previously shown to be linked to grip strength.[33 34] This could be the reason why students with a grip strength of more than 35 kg were more likely to correctly identify pregnant cows than students with a grip strength of less than 35 kg.

The finding that students' use of their preferred hand for TRPs was not associated with PD sensitivity or specificity could be explained by the fact that the majority of students (78 per cent) preferred the left hand while the on-farm examination crush used during the student PD assessment required left hand palpation. If a higher percentage of students would have had to palpate with their non-preferred hand, an association might have been detected.

The majority of students enjoyed the one-week training programme (91 per cent), recommended implementation thereof as an annual event within the VEP workplace-based student training (80 per cent) and found the live cow PD exposure in private practice beneficial (60 per cent). This supports the initiative to incorporate this programme for production animal elective students as an annual event. Interestingly, 39 per cent of students did not find the rectal examination simulator (BB and Haptic Cow) training beneficial, which suggests that simulator training at this stage in the students' career might be too late as previous live cow experience outweighs the simulator training benefits. This is in accordance with a previous study reporting that students with previous live cow PD experience had negative opinions concerning BB training, while students without any prior live cow PD experience were exclusively positive.[3] This underpins a previous recommendation of simulator training earlier in the curriculum before live cow palpations,[3] and can be used to adjust the one-week training programme to make simulator training a voluntary exercise for interested students.

One limitation of this study is that only students interested in production animal practice were included in this study. Career interest can influence PD accuracy,[3] and this may have influenced the results of this study. Therefore, these findings may not be applicable to students with other career interests. Another limitation of this study is that sample size calculations were not performed. This is due to the fact that the number of participants was limited by the number of students who volunteered and by available spaces within the training programme based on private practice placements. Furthermore, including a control student cohort participating in the two OSCE assessments without the intense training to justify that just retaking the OSCE would not improve their OSCE scores would have added valuable information to the study. Lastly, it would have been beneficial to assess students' PD performance pretraining and post-training instead of only after the training period. However, animal availability and ethical considerations regarding palpation frequency of available cows influenced the latter two study limitations.

Conclusion

In conclusion, a one-week intense training programme is an appropriate strategy to improve students' TRP OSCE scores and palpation abilities through implementation of focused live cow access via private practice placements during the later stages of the curriculum for selected students intending to follow a career in food animal practice. This approach has the potential to overcome training limitations including animal use constraints at teaching institutions. The importance of intense supervision and feedback by a veterinarian during such a training programme is emphasised.

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Competing interests None declared.

Ethics approval This study was approved by the Animal Ethics and Research Committee of the University of Pretoria (project number SOP038-18). No cow was palpated more than three times in one session at any stage during the experiment, and cows in the commercial herd were only palpated on one of the two assessment days.

Data availability statement All data relevant to the study are included in the article.

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