

Differential performance on the Canadian Chiropractic Examining Board Examinations: an eight year longitudinal study

Douglas Lawson, DC*
 Claudio Violato, PhD**
 Anthony Marini, PhD**
 Murray McEwen, DC*

Performance data from the Canadian Chiropractic Examining Board (CCEB) examinations for an eight year period, 1987-1994, were analyzed. These exams sample nine content areas: anatomy, chemistry, chiropractic practice, diagnosis and symptomatology, microbiology and public health, neurology, pathology, physiology, and x-ray interpretation and physics. Candidates from more than 15 chiropractic colleges have written the CCEB exams over this eight year period. The results indicate that there are substantial differences on mean performance by graduates of the various chiropractic colleges that wrote the CCEB during the study period. Factors possibly contributing to these differences are proposed. The implications for educational program evaluation and curricular revisions are discussed.
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KEY WORDS: licensure examinations, program evaluation, chiropractic education.

It is common practice to monitor and evaluate the performance of educational institutions at every level with examinations external to the institution (Ralph, Keller and Crouse, 1994).¹ Professional schools are frequently evaluated this way. The effectiveness of some 126 medical schools in the United States, for instance, is regularly evaluated comparatively by examining differential performance of their graduates on the National Board of Medical Examiners (NBME) Subject Examinations and the more recent United States Medical Licensing Examination (USMLE) (Kappleman, 1983; Williams, 1993).^{2,3} Canadian Medical Schools are similarly evaluated employing the Medical Council of Canada (MCC) licensing examinations (Dauphinee, 1981; Maguire, Skakun and Harley, 1992).^{4,5} Such

Les données relatives à la performance aux examens du Canadian Chiropractic Examining Board (CCEB) sur une période de huit ans (1987 à 1994) sont analysées. Ces épreuves portent sur un échantillon de neuf disciplines : anatomie, chimie, pratique de la chiropraxie, diagnostic et symptomatologie, microbiologie et santé publique, neurologie, pathologie, physiologie, interprétation des radiographies et physique. Des candidats provenant de plus de 15 collèges de chiropraxie se sont présentés à l'examen du CCEB sur une période de huit ans. Les résultats montrent qu'il existe des différences substantielles sur la performance moyenne entre les diplômés des différents collèges de chiropraxie qui se sont présentés au CCEB pendant la période étudiée. On passe en revue certains facteurs susceptibles d'avoir induit ces différences. On discute des répercussions sur l'évaluation des programmes éducatifs et sur la révision des programmes.
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MOTS-CLES : examens pour le permis d'exercice, évaluation des programmes, enseignement chiropratique.

reviews are thought to be useful for monitoring and thus possibly improving the content and delivery of curriculum and teaching effectiveness of the institutions. The data from such external exams can be used for evaluating general educational programs as well as specific innovations. Generally they can be used for monitoring the performance of graduates from different institutions. Such inter-institutional analyses have never been conducted with the Canadian Chiropractic Examining Board (CCEB) examinations. These exams must be successfully passed by all candidates who wish to take the provincial board examinations for chiropractic licensure. The main purpose of the present study was to analyze the performance of candidates on the CCEB examinations over an eight year period, 1987-1994. These exams measure nine subject content areas: anatomy, chemistry, chiropractic practice, diagnosis and symptomatology, microbiology and public health, neurology, pathology, physiology, and x-ray interpretation and physics.

External examinations such as those administered by the CCEB or the MCC are standardized measures whereby all candidates can be compared on a standard metric. Such a metric resolves the problem of trying to compare between-institu-

* Canadian Chiropractic Examining Board.

** University of Calgary and Edumetrics Ltd.

Correspondence to Dr. Douglas Lawson, 1020 Centre Street North, Calgary, Alberta T2E 2P9, phone (403) 230-9003; fax (403) 277-8162.

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tion performance based on grade averages assigned by the institutions themselves. It is well known that these averages are notoriously unreliable (Elam and Johnson, 1994).⁶ By using aggregate analysis (i.e. group comparisons) on standard measures, a number of inferences can be made about the institutions from which candidates have graduated. These include judgements about the (1) efficacy of the overall program, (2) the appropriateness of the content and emphasis of the curriculum, (3) effectiveness of the curriculum delivery (e.g. pedagogical efficacy), (4) effectiveness of innovations in teaching and learning environments (e.g. problem-based learning, self-directed learning), (5) appropriateness of entry selection procedures, and (6) stability of performance over time of different cohorts.

Williams (1993)³ has advocated the use of standardized instruments for evaluating programs generally. Instruments which are administered under controlled conditions, yield meaningful bases for comparisons with other programs and with past performance of the same program, are particularly suited for evaluation of programs. In the chiropractic education of Canadian chiropractors, the CCEB examinations are the only data sources that satisfy this demand. Moreover, they are useful for evaluating the content and emphasis of particular curricula at any given institution. If graduates from that institution perform consistently well on particular subject tests, this indicates that content area is given good coverage and emphasis at that institution. Conversely, persistently poor performances may indicate inadequacies in the content and emphasis of that institution's curriculum. If upon examination the actual content and emphasis of a particular institution's curriculum seems appropriate, performance on the external examinations may reflect the effectiveness of curriculum delivery (i.e. teaching effectiveness of the faculty).

Innovations in teaching and learning can also be evaluated by graduates' performance on external examinations. Mennin, Friedman, Skipper, Kalishman and Snyder (1993),⁷ for example, evaluated the performance on the NBME examinations of 508 graduates of the conventional track (teacher centred) with 167 problem-based Primary Care Curriculum (PCC) (student centred) track graduates at the University of New Mexico School of Medicine from the classes of 1983–1992. They concluded that in the short run, the more teacher centred and structured conventional curriculum better prepared the students for the examinations. In the long run, however, the more student-centred problem-based curriculum was expected to better prepare the students for the "problem-solving" clinical practice of the undifferentiated physician as was indicated on Part II portion of the NBME. Such evaluations of the efficacy of innovations like problem-based curriculum, can be of critical importance to both the institution and the profession as a whole.

Another important use of external examinations are inferences about the entry selection procedures of colleges and professional schools. Persistently poor performance of some graduates may indicate inappropriate entry selection procedures of that insti-

tution (e.g. Elam and Johnson, 1994).⁶ Provided with such information, an institution may wish to review its selection procedure for admission. Finally, highly variable performance from year to year from graduates of the same institution on the external exams can mean several things such as unstable teaching, inconsistent curriculum emphasis or questionable selection procedures.

The foregoing discussion indicates that external examinations such as those of the CCEB, may properly be considered as useful tools in providing information of the performance of candidates from various chiropractic colleges. Issues related to curriculum emphasis, instructional delivery models and admission criteria, can all be potentially addressed by such data. Given the value of longitudinal data for educational institutions, the present study was undertaken to analyze the performance on the CCEB examinations over an eight year period, 1987–1994.

Method

Subjects

The data from a total of 1,592 candidates (1,167 men – 73.3%; 425 women – 26.7%) who wrote the CCEB exams from 1987 to 1994 inclusive, were analyzed in the present study. The number and percentage of subjects who wrote the exams for each year are as follows: 1987, $n = 162$ (10.2%); 1988, $n = 165$ (10.4%); 1989, $n = 191$ (12.0%); 1990, $n = 129$ (8.1%); 1991, $n = 206$ (12.9%); 1992, $n = 226$ (14.2%); 1993, $n = 252$ (15.8%); 1994, $n = 261$ (16.4%). Candidates from more than 15 chiropractic colleges (see Tables 1 and 2 for a breakdown) wrote the exams over the eight year period of the study.

The CCEB exams

The current CCEB test battery which is administered over the course of one week, consists of nine subject tests: anatomy, chemistry, chiropractic practice, diagnosis and symptomatology, microbiology and public health, neurology, pathology, physiology, x-ray interpretation and physics. Each test is composed of 75 multiple-choice items that are either selected from an existing computerized item-bank, are created by subject area experts, or by test construction committees. Each test is ultimately created, finalized and edited by test construction committees that are composed of five people – a careful mix of subject area experts, general chiropractors and one Ph.D. level expert in testing. The committees meet during the winter to prepare the exams for administration in April.

Because the items are created, revised and edited according to rigorous standards of technical quality (Haladyna and Downing, 1989; Marini and Violato, 1992)^{8,9} and item-analyzed after administration, content validity is enhanced (Gronlund and Linn, 1990).¹⁰ Moreover, content validity is further enhanced as the relative weighting of the sub-content areas and level of cognitive outcome (i.e. knowledge, comprehension, higher order processes), are carefully determined by

employing a detailed table of specifications (Violato, McDougall and Marini, 1992).¹¹

Reliabilities from the CCEB battery (internal consistency estimates – Cronbach's alpha coefficient) for 27 tests (from the 3 year period, 1992–1994) ranged from .75 to .85 with a mean coefficient of .80. This indicates that the tests have good to excellent reliability (Cronbach, 1990; Violato et al., 1992).^{11, 12} These data together with the content validity criteria indicate that the CCEB examinations have appropriate psychometric properties.

Data were obtained on all of the subtests of the CCEB examinations for all candidates who wrote these tests from 1987 to 1994 inclusive. Grade averages from the chiropractic colleges from which the candidates graduated were also obtained.

Results

The results are reported under three headings: 1) Longitudinal results, 2) Subject area results, and 3) Grade average analyses.

Longitudinal results

In order to compare performance among colleges as well as to evaluate their stability over time, a composite score was computed for each candidate across all nine subject area examinations for each year. These composite scores for five colleges and an "other" category, were analyzed for differences for each of the eight years (87–94). The colleges were the Canadian Memorial Chiropractic College (CMCC), Palmer College of Chiropractic-Davenport (Palm), Palmer College of Chiropractic-West (PalmW), Logan College of Chiropractic (Logan), Western States Chiropractic College (WSCC), and "other" (Anglo-European College of Chiropractic, Northwestern College of Chiropractic, Los Angeles College of Chiropractic, Life College of Chiropractic, Life College of Chiropractic-West, Parker College of Chiropractic, Cleveland Chiropractic College, National College of Chiropractic, Texas College of Chiropractic, Philip Institute of Technology, School of Chiropractic and Osteopathy). For each of the eight years, the differences between colleges on composite scores were analyzed by analysis of variance (ANOVA). The one-way ANOVAs with college as the independent variable and composite score as the dependent variable revealed that there were significant differences in the mean scores in each of the eight years (see Table 1). The relevant F ratios, degrees of freedom and probability levels for each year were as follows:

1987, $F(4,157) = 18.9, p < .01$;
1988, $F(3,161) = 22.5, p < .01$;
1989, $F(5,185) = 23.6, p < .01$;
1990, $F(4,124) = 25.5, p < .01$;
1991, $F(5,200) = 10.5, p < .01$;
1992, $F(5,220) = 13.3, p < .01$;
1993, $F(5,246) = 34.5, p < .01$;
1994, $F(5,255) = 28.1, p < .01$.

For a more fine-grained analysis and to determine where the composite scores differences were significant, Tukey's (Hays,

1988)¹³ multiple range test (HSD) was used to analyze between college difference for each year ($p < .05$ was used as the critical value). Based on these differences, the colleges were assigned a rank-order within each year. These data are summarized in Table 1 as is the number of candidates (N) upon which each analysis is based. Thus, the same rank indicates that those colleges are not significantly different from each other but they are different from those with a different rank. In 1987, for example, CMCC, Logan and WSCC all tied with rank 1, indicating that there were no significant differences among them. In that same year, however, Palm and "other" ranked 2 meaning that they did not differ from each other but were below the rank 1 colleges (see Table 1). In order to further clarify these results and depict their stability, they were graphed using a time series analysis (Figure 1).

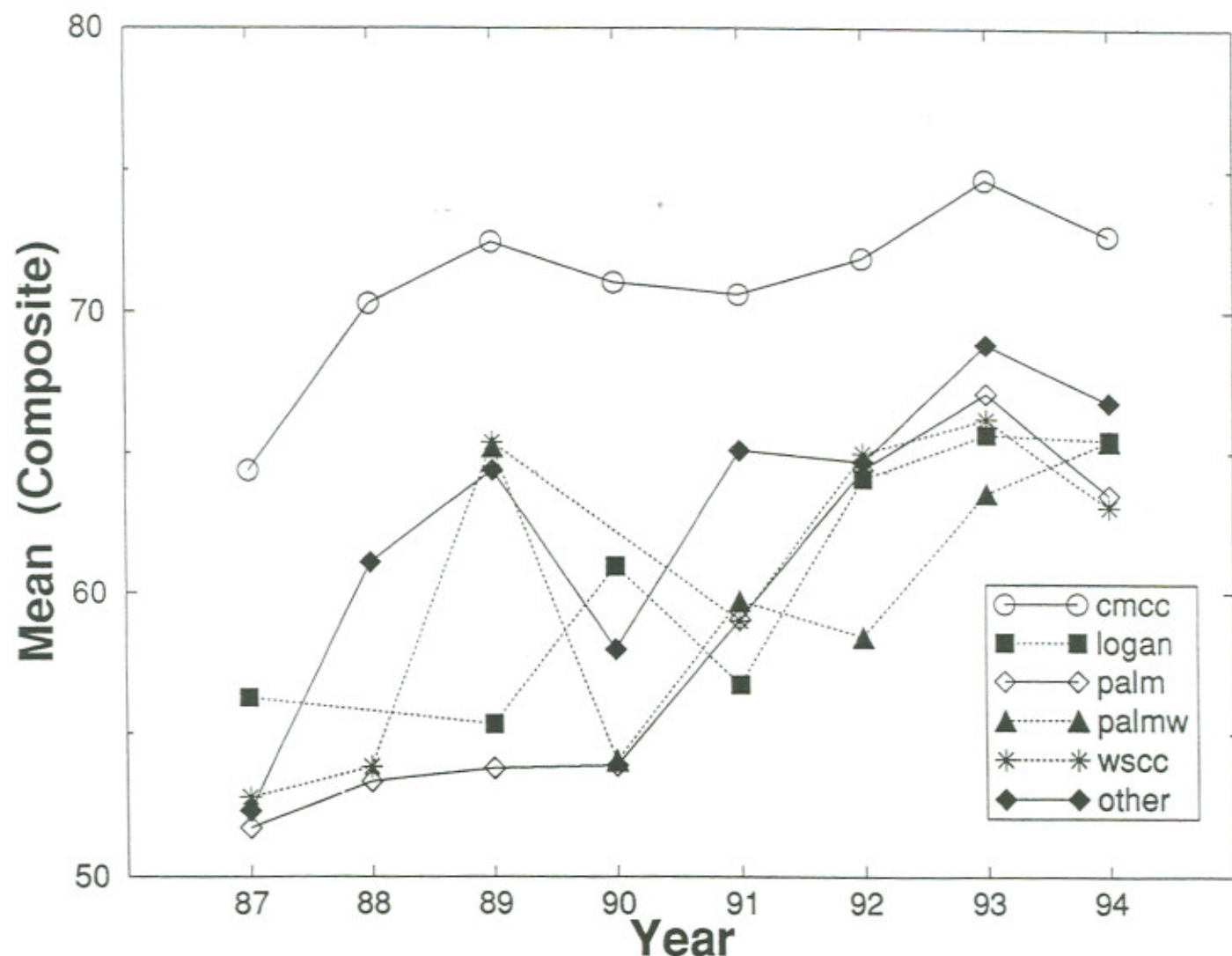
From the results summarized in Table 1 and Figure 1 it is evident that CMCC graduates consistently perform as well as or better than graduates from all other colleges. They clearly outperform all of the graduates from the other colleges for all of the years except for 1988 and 1992 where they were tied with WSCC in 1992 for rank 1 and several others in 1988 for the top rank. Moreover, while the performance of CMCC graduates is very consistent across the eight year period, performance of graduates from the other colleges is characterized by inconsistency. WSCC graduates, for example, show considerable inconsistency occupying all three ranks across the eight year period. Both Palmer and Logan graduates show inconsistency intermediate between CMCC and WSCC over the eight year period. The miscellaneous grouping "others" shows similar inconsistency (Table 1 and Figure 1).

Subject area results

In order to analyze the consistency-inconsistency of performance on the nine subject area tests, scores were combined across all eight years so that there would be sufficient data to compare among and between colleges. This combining allowed for comparisons among 13 colleges (see Table 2). As before, to test for significant differences between colleges, the data were analyzed by ANOVA for each subject area. To test for overall differences, multivariate analysis of variance (MANOVA) was employed. A one-way MANOVA with 9 dependent variables (the subject tests) and college as the independent variable showed a significant overall difference (Wilk's Lambda = 0.62, Approximate $F(108,11450) = 7.22, p < .01$). Significant differences emerged for each of the nine subtests:

Anatomy,	$F(11,1580) = 34.7, p < .01$;
Chemistry	$F(11,1580) = 25.0, p < .01$;
Physiology,	$F(11,1580) = 26.2, p < .01$;
Chiropractic Practice,	$F(11,1580) = 30.0, p < .01$;
Diagnosis and Symptomatology,	$F(11,1580) = 18.6, p < .01$;
Microbiology and Public Health,	$F(11,1580) = 34.7, p < .01$;
Neurology,	$F(11,1580) = 27.5, p < .01$;
Pathology,	$F(11,1580) = 45.0, p < .01$;
X-ray Interpretation and Physics,	$F(11,1580) = 23.3, p < .01$.

FIGURE 1
Mean of the Composite Score on the CCEB Exams
of Six Colleges for an Eight-Year Period



For a more fine-grained analysis and to determine significant differences between colleges for each of the subtests, Tukey's multiple range test (HSD) was employed as before ($p < .05$). The results from these analyses are summarized in Table 2. As in the previous analyses, same ranks were assigned to colleges that did not differ. As can be seen from Table 2, graduates from CMCC consistently outperformed all other candidates or were tied with them for rank 1. Conversely, graduates from LCCW and PKCC scored consistently in the lowest rank on all subtests ("other" = Cleveland Chiropractic

College, National College of Chiropractic, New York Chiropractic, Northwestern College of Chiropractic, Texas College of Chiropractic, Philip Institute of Technology, School of Chiropractic and Osteopathy). With the exception of CMCC graduates who show remarkable consistency across all subject areas, there appears to be only two general areas of weakness: Anatomy and Pathology (Table 1). By contrast, performance on Chiropractic Practice, Diagnosis and Symptomatology, x-ray Interpretation and Physics, and Chemistry is comparatively homogeneous across all colleges. Together with graduates from

TABLE 1
Performance of Candidates from Varying Colleges
for the Composite of the CCEB Exams for the Period 1987-1994

COLLEGE	N	YEAR							
		87	88	89	90	91	92	93	94
1. CMCC ^c	1,014	64 ^a (1) ^b	70(1)	72(1)	71(1)	71(1)	71(1)	75(1)	73(1)
2. Palm	143	52(2)	53(2)	54(3)	54(3)	59(3)	64(2)	67(2)	64(3)
3. PalmW	82	—	—	62(2)	54(3)	60(3)	58(3)	64(3)	65(2)
4. Logan	56	56(1)	—	55(3)	61(2)	57(3)	64(2)	66(2)	65(2)
5. WSCC	55	53(1)	54(2)	63(2)	—	59(3)	65(1)	66(2)	63(3)
6. Other	242	52(2)	61(2)	64(2)	58(2)	65(2)	65(1)	69(2)	67(2)

^a Mean (in percent) for the composite score across all nine subject exams.

^b Rank-order: Those receiving the same rank are not statistically different from each other but are different from those receiving a different rank ($p < .05$).

^c CMCC = Canadian Memorial Chiropractic College; Palm = Palmer College of Chiropractic - Davenport; PalmW = Palmer College of Chiropractic - West; Logan = Logan College of Chiropractic; WSCC = Western States Chiropractic College; Other = see text for explanation.

TABLE 2
Performance of Candidates from Varying Colleges
on the Nine Subject Examinations

COLLEGE	N	SUBJECT EXAMINATION								
		ANAT	PHYS	CHIR	DIAG	MICR	NEUR	PATH	XRAY	CHEM
1. CMCC ^c	1,014	71 ^a (1) ^b	71(1)	71(1)	72(1)	71(1)	71(1)	71(1)	71(1)	71(1)
2. Palm	143	60(4)	60(3)	60(2)	62(2)	60(2)	61(2)	57(3)	60(2)	61(2)
3. PalmW	82	60(4)	65(2)	62(2)	64(2)	62(2)	61(2)	60(2)	61(2)	62(2)
4. AECC	18	64(3)	61(3)	61(2)	64(2)	57(3)	64(1)	64(2)	66(1)	61(2)
5. NWCC	41	65(2)	71(1)	66(1)	71(1)	67(1)	67(1)	65(2)	68(1)	72(1)
6. Logan	56	60(4)	64(2)	64(2)	64(2)	63(2)	64(2)	62(2)	62(2)	65(1)
7. LACC	27	61(4)	61(3)	63(2)	64(2)	61(2)	64(2)	59(3)	62(2)	62(2)
8. WSCC	55	65(2)	69(1)	68(1)	71(1)	69(1)	69(1)	66(2)	68(1)	72(1)
9. LCC	46	58(4)	60(3)	60(2)	64(2)	60(2)	61(2)	59(3)	61(2)	60(2)
10. LCCW	25	59(4)	60(3)	61(2)	63(2)	58(3)	60(2)	58(3)	59(2)	62(2)
11. PKCC	32	61(4)	62(3)	60(2)	61(2)	60(2)	59(3)	62(2)	60(2)	63(2)
12. Other	53	61(4)	64(2)	63(2)	65(2)	64(2)	64(2)	62(2)	61(2)	67(1)

^a Mean score (in percent) computed across the eight year period, 1987-1994.

^b Rank-order: Those receiving the same rank are not statistically different from each other but are different from those receiving a different rank ($p < .05$).

^c CMCC = Canadian Memorial Chiropractic College; Palm = Palmer College of Chiropractic - Davenport; PalmW = Palmer College of Chiropractic - West; AECC = Anglo-European College of Chiropractors; NWCC = Northwestern College of Chiropractic; Logan = Logan College of Chiropractic; LACC = Los Angeles College of Chiropractic; WSCC = Western States Chiropractic College; LCC = Life College of Chiropractic; LCCW = Life College of Chiropractic - West; PKCC = Parker College of Chiropractic; Other = see text for explanation.

CMCC, those from WSCC and Logan are notable in a comparative strong performance across most subject areas (with the exception of anatomy and pathology as noted above). It is quite clear, however, that the pattern of performance varies substantially across colleges and subject areas.

Grade average analysis

Grade averages are provided to the CCEB for candidates who register to take the CCEB examinations. These are provided in varying forms depending on the practice of the graduating institution. For the present analyses, all grade averages were converted to a four-point scale (GPA) which is in common use. The mean GPA across all candidates for the eight year period was 3.11 (minimum = 2.78, maximum = 4.00, standard deviation = .34). To test for potential differences of GPA across college, a one-way ANOVA was used with college as the independent variable. The results indicated significant differences ($F(11,1408) = 3.02, p < .01$). Tukey's HSD test showed that Palmer College of Chiropractic-Davenport (mean GPA = 3.21) and Western States Chiropractic College (mean GPA = 3.23) had higher mean GPAs than the other colleges. The candidates from the Canadian Memorial Chiropractic College who as we have seen outperformed candidates from the other colleges on average on the CCEB examinations, did not differ on mean GPA (3.10) from the rest. The average correlation between GPA across all candidates for all eight years and all subtests was, $r = .43$ (min $r = .38$; max $r = .47$).

Discussion

The major findings of the present study may be summarized as follows: 1) The pattern of performance on the CCEB exams over the eight year period (1987-1994) is very stable, 2) Candidates from some colleges clearly outperform candidates from others with those from CMCC doing best on the average, 3) Only two subject areas (anatomy and pathology) emerged as weak areas in general while performance in the other seven areas was quite homogeneous across colleges, and 4) GPAs showed minor differences across colleges and substantial correlations overall with all nine subtests of the CCEB examinations.

While the reasons for these differences between colleges are undoubtedly complex, the results from the present study can be a starting point for colleges to address issues that are of particular concern to them. Some colleges, for example, may want to review their anatomy courses and their teaching of anatomy. Pathology is another area that some colleges may wish to review. Similarly, some colleges may wish to review their entry admission criteria based on the results from the present study. Obviously, any review will involve an examination of much other data and information than only performance on the CCEB exams, but this may indicate a possible starting point. Any program evaluation must, of course, be done with the specific goals and educational objectives of that institution in mind. Nevertheless, results on these external exams can be

very valuable in the overall evaluation of chiropractic educational programs.

If there are two problem curriculum areas that can be identified in the present study it is anatomy and pathology. These areas appear to be problematic at several institutions judging from their graduates' performance on these exams. Conversely, almost all of the colleges in the present study seem to be preparing their graduates comparatively well on Chiropractic Practice, Diagnosis and Symptomatology, x-ray Interpretation and Physics, and Chemistry. In the identified problem areas (anatomy and pathology) it may be that there are curriculum emphasis problems, or poor curriculum delivery (i.e. ineffectual teaching in these areas). Institutions concerned about these areas might wish to carefully evaluate their educational programs in these subjects.

Notwithstanding the robust and stable findings in the present study involving a large number of candidates overall, at least one caveat is in order. While there are a very large number of candidates from CMCC who have taken the CCEB exams over the period of this study (1,014), some colleges have contributed a very small group by comparison. Only 18 graduates from AECC, for example, are in the present study (25 from LCCW, 27 from LACC). It is possible, therefore, that such few graduates are not representative of the general graduates at that college. While this possibility cannot be conclusively ruled out, it is important to note that the mean GPA of these candidates is not less than that of CMCC. Indeed, for two colleges (Palmer-Davenport and WSCC) the mean GPAs are significantly *higher* than those of the other colleges. These results indicate, therefore, that the candidates from these various colleges are probably representative of the general graduates at least on GPA. From the GPA data, there is no other reason to suppose that only the lowest achieving candidates from these colleges are writing the CCEB examinations. Further research into this issue of representativeness is required, however, before firm conclusions can be made about those colleges as a whole. In any case, for whatever reason, it is clear that there is substantial differential performance on the CCEB examinations by graduates of various colleges and this is stable over time and across subject area.

Summary and conclusions

As has been proposed by others (e.g. Kappleman, 1983; Williams, 1993),^{2,3} external standardized examinations may be useful for evaluating educational programs of professional schools. The CCEB examinations are important data sources that meets the requirements for this in the chiropractic education of Canadian chiropractors. Since these examinations must be written by all candidates who will ultimately practice in Canada, and since these test are external standardized instruments with appropriate psychometric properties, they are a rich and valuable data source for program evaluation. As we have seen in the present study, results from these tests can indicate strengths and weaknesses in both-the curricular con-

tent and emphasis of different institutions. These results can be an important tool for the chiropractic colleges themselves for improving their entry selection procedures, curriculum and teaching effectiveness.

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