**Original Research Article**

# ANATOMICAL KNOWLEDGE RETENTION IN PHYSIOTHERAPY STUDENTS: A PRELIMINARY ASSESSMENT

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## ABSTRACT

**Introduction:** Anatomical knowledge and understanding are key components of physiotherapy education and practice. Traditionally, anatomy has been taught as a foundation stream within the first year(s) of physiotherapy education. This curricular model is based on the assumption that further learning in subsequent years builds upon the knowledge gained in the early stages of the program. However, the retention rate in all basic sciences has often been called into question. In anatomy, several studies suggest that anatomy knowledge endures considerable attrition, highlighting the need for the evaluation of retention rates. This paper aimed at making a preliminary assessment of the knowledge and retention of anatomy among physiotherapy students.

**Materials and Methods:** We used a carpal bone identification test and assessed 129 first year and 113 fourth year physiotherapy students.

**Results:** 20% of the students managed to identify all bones while 47% were able to identify more than five bones. The best recognised bones were pisiform and scaphoid while the most difficult to identify were trapezium and trapezoid.

**Conclusion:** Overall, first year students performed better than their fourth year counterparts which suggested attrition of anatomical knowledge. Educational strategies based on revision, integration and clinical application of anatomy could contribute towards the decrease of attrition of anatomical knowledge.

**KEY WORDS:** Anatomy Education, Retention, Physiotherapy, Carpal Bones.

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| Access this Article online | |
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| **Quick Response code**<br><br>**DOI:** 10.16965/ijar.2016.485 | **Web site:** International Journal of Anatomy and Research<br>ISSN 2321-4287<br>www.ijmhr.org/ijar.htm |
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## INTRODUCTION

The education of health professionals traditionally starts with a good grounding in basic sciences, which are meant to impart students with a good understanding of the structures and functions of the human body at different organisational levels as well as its development and environmental interactions.

Anatomy has figured prominently among the basic sciences, being of particular importance in some professions and specialties. In physiotherapy, anatomy has a central place in education as detailed knowledge of the structures of the human body, particularly the musculoskeletal

al system, is essential for safe and efficient practice. Indeed, in Australia where this research was carried out, anatomy played a key role in physiotherapy curricula since the first programs were established at the beginning of the twentieth century. In these early curricula anatomy was taught in detail and through dissection, over both years of what was then a two year diploma course [1,2].

One of the main issues in teaching and learning basic sciences in general and anatomy in particular has been the retention rate. It was estimated in a recent review that "in the general educational domain as well as in medical education, approximately two-third to three-fourth of knowledge will be retained after one year, with a further decrease to slightly below fifty percent in the next year" [3]. There is, therefore, a considerable concern among medical educators that the attrition of basic science knowledge might have negative implications in regards to acquiring clinical skills. Consequently, a number of educational strategies were devised in order to improve the retention rate, all based on the need to repeat, revise and apply the knowledge from basic sciences [3].

The regular assessments of the level of basic science knowledge at different stages of study and of its retention rate are therefore a necessity in constantly evolving health curricula. This, however, is a complex process as recent research demonstrates considerable differences between different basic sciences and, indeed, diverse retention rates between various subjects and topics within the same discipline [3-5].

The aim of this study was to provide a preliminary assessment of the retention of anatomy knowledge among the physiotherapy students at Curtin University in Perth, Australia. Curtin University is one of the nineteen tertiary institutions in Australia offering a degree in physiotherapy [6]. Anatomy instruction at this university, similarly to most of the others, is carried out predominantly in the first year of studies. Anatomy teaching at Curtin has a strong practical component where students inspect and study (but do not dissect) prosected cadavers in the anatomy laboratory. Although all systems are covered, the main focus in anatomy educa-

tion is on the structures belonging to the musculoskeletal system.

The preliminary assessment of the retention rate in anatomy was investigated through the use of a simple test in which students were asked to identify carpal bones [7]. This "carpal bone test" and different versions of it has already been utilised in a number of studies to provide an initial estimate of the level of knowledge and retention rate in anatomy among the students and recent graduates in a number of health disciplines [7-11].

## MATERIALS AND METHODS

Ethical clearance for this study was obtained from the Curtin University Human Research Ethics Committee. The carpal bone test was completed by first and fourth year physiotherapy students. The fourth year students were a cohort of pre-registration physiotherapy students with no formal anatomical education within the previous two years while the cohort of first year students had just completed their foundational anatomy course. The students were approached to complete the test based on the identification of carpal bones from a diagram to evaluate their knowledge of anatomy. Students had no prior knowledge of the task.

The fourth year physiotherapy students were given the test at the end of their final year prior to completing their final qualifying examination. The first year students were given the test after their final anatomy examination. Both sets of students were given a maximum time of five minutes to complete the task. The tests were the same for both sets of students and participation in the completion of the task was completely voluntary. The students were notified that this test was not part of their University assessment and thus no names or student numbers were collected with the completed task. Returning an attempt of the test constituted consent to participate. The test also included an information sheet to state the objectives of the study.

The test consisted of a diagram illustrating the skeleton of the hand and the wrist region containing all of the carpal bones in situ. Students were asked to identify and name each of the carpal bones on the diagram.

Tests were corrected and the results were evaluated using IBM SPSS, statistical software version 22.0 (IBM Corp, Armonk, NY). A chi-squared test was employed to determine the difference in frequencies between the first and fourth year responses across three bands of correct response (all correct, six or more correct and four or more correct) with alpha set at 0.05.

## RESULTS

Of the 181 first year students enrolled, 129 completed the tasks, while 113 of the 141 enrolled students in the fourth year completed the task. This resulted in a response rate of 71% and 80% respectively for the first and fourth years. Responses to the test were evaluated as either: correct, incorrect or not attempted.

The results are reported separately for first and fourth years and then together as a cohort of physiotherapy students (Figs. 1-3). The pisiform was correctly identified most of the times by the first year students (Fig. 1), while the scaphoid was the most correctly identified carpal bone by the fourth year students (Fig. 2). The capitate was mostly not attempted in both the groups. The trapezoid and trapezium were the two bones that were the most incorrectly identified by both groups (Fig. 3).

All eight bones were correctly identified by 49 (20%) students out of the 242 respondents (Fig. 4). Of these 49 students, 39 were first year students. A total of 114 (47%) students were able to identify more than five bones correctly and 74 of these were first years. Seventeen percent of the entire cohort was not able to identify any of the carpal bones. This included the students who had not even attempted to identify any of the bones.

The number of bones most correctly identified by first years was eight (Fig. 4), while fourth year students correctly identified four bones, but the same percentage of fourth year students also did not correctly identify any bones (Fig. 4).

Thirty nine first year students and ten fourth year students correctly identified all eight carpal bones indicating a statistically significant association between year group and correct identification of all carpals ($\chi^2_{(1)}$ = 17.1,

p = 0.005). Similar significant associations were found between year group and number of correct responses when performed examining students who got six or more bones correct (62 year 1 vs 29 year 4; $\chi^2_{(1)}$ = 12.9.1, p = 0.005) and those students who got four or more bones correct (86 year 1 vs 61 year 4; $\chi^2_{(1)}$ = 4.1, p = 0.04). There was no statistical difference between "not attempted" response rates between years ($\chi^2_{(1)}$ = 0.6, p = 0.439).

**Fig. 1:** The percentage of students in the first year that correctly identified; incorrectly identified and did not attempt identifying the carpal bones.
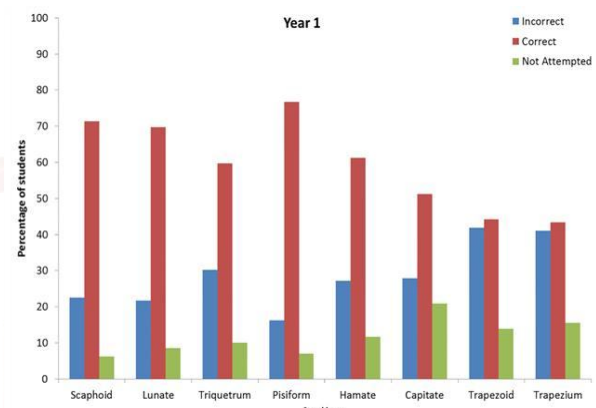


**Fig. 2:** The percentage of students in the fourth year that correctly identified; incorrectly identified and did not attempt identifying the carpal bones.
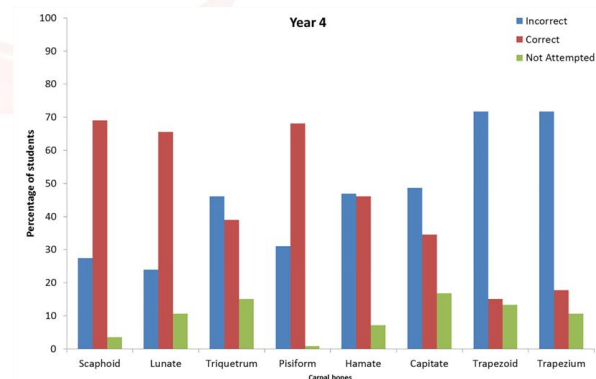


**Fig. 3:** The percentage of all students in the first and fourth year that correctly identified; incorrectly identified and did not attempt identifying the carpal bones.
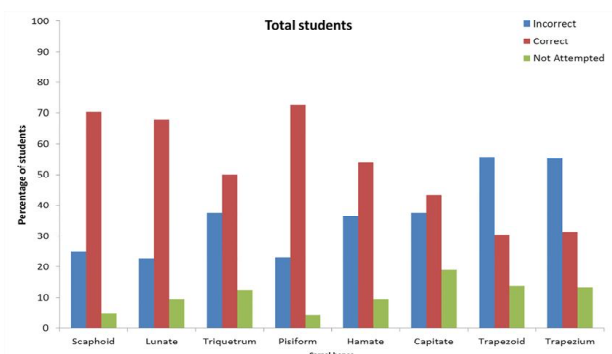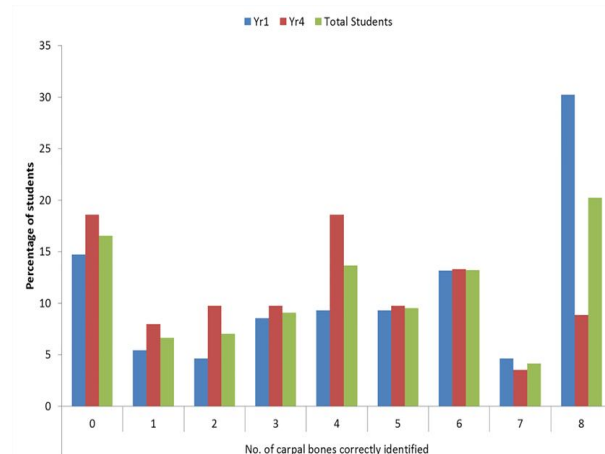
**Fig. 4:** The percentage of correctly identified carpal bones for the first year and fourth year students.



## DISCUSSION

The results of this study indicate good knowledge of the carpal bones anatomy of the students who have just finished their anatomy course and somewhat lower level of knowledge among the students in their final year. While it is difficult to generalise these results, one might hypothesise that, as anatomy is taught in the first year of study at most of the Australian universities (and those from other countries), similar patterns could be expected in some of the other physiotherapy programs. Whether this level of knowledge is satisfactory and sufficient for the safe practice is difficult to establish when these results are looked in isolation [12,13]. When compared to the results of other similar studies, however, certain relevant educational issues and patterns start to emerge (Table 1).

**Table 1:** Comparison of the percentage of correctly identified carpal bones.

| | Spielmann et al. 2005 [7] | Strkalj et al. 2011 [8] | Valenza et al. 2012 [9] | | Meyer et al. 2015 [11] | | Present study | |
|---|---|---|---|---|---|---|---|---|
| Number of bones | Medical | Chiropractic | Medical | Physical Theray | 2nd Year Chiropractic | 5th Year Chiropractic | 1st Year Physiotherapy | 4th Year Physiotherapy |
| 7, 8 | 30 | 42 | 3 | 33 | 48 | 98 | 35 | 13 |
| 5, 6 | 16 | 18 | 24 | 39 | | | 22 | 23 |
| 3, 4 | 36 | 13 | 23 | 39 | 52 | 2 | 18 | 28 |
| 0,1,2 | 18 | 27 | 51 | 0 | | | 25 | 36 |
| Completed questionnaires | 50 | 84 | 80 | 54 | 47 | 44 | 129 | 113 |
| Most frequently identified bone | Scaphoid | Pisiform | Capitate | Capitate | Pisiform | Scaphoid, Lunate | Pisiform | Scaphoid |

There are some commonalities in students' performance across different levels of study, health professions and institutions. The bone most frequently identified by most groups of students previously tested, including those from the current study, was the scaphoid while

trapezium and trapezoid seem to be the most commonly unrecognised, misidentified and mixed up. With the scaphoid being the carpal bone most often fractured, this pattern of identification clearly demonstrates the importance of application of anatomical knowledge and deep learning associated with it. In the reverse case of the trapezium and trapezoid - bones with similar names and closely associated in their position within the carpus – students' failure to identify them may show how the complexities of anatomical terminology strongly affect the learning process.

A study carried out at the University of Granada in Spain [9] suggested that third year physical therapy students performed better at the carpal bone test than third year medical students [9]. The results of the present study corroborate this as our sample of physiotherapy students also performed better than the medical students in Spain and those from the UK, tested at the Edinburgh University Medical School [7]. This is to be expected as physical therapy/physiotherapy students generally study the musculoskeletal system in more detail and depth than their medical counterparts, who usually adopt more of the relevant anatomy only if they specialise in one of the areas that requires such knowledge, such as orthopaedic surgery. Thus, although both groups of students at the University of Granada received similar instruction on the carpal bones in their first year, subsequent physical therapy education included "specific musculoskeletal area" focus while the medical was "a broader education covering many different systems and areas" [9].

The fact that the final year students in this study showed less knowledge of carpal bones anatomy than their first year colleagues might be a reason for some concern. In contrast, in the test of first and fourth year podiatry students from three Spanish universities (who were, appropriately, tested on the anatomy of tarsal, rather than carpal bones) there was no significant difference in performance between the two generations [10]. In a similar study utilising the carpal bones test, fifth year chiropractic students at Australia's Murdoch University performed better than their second year counterparts, who had just finished their anatomy course [11].

However, research conducted on medical students and recent graduates from the Edinburgh University study, suggests that once the graduates enter the internship and clinical practice, their knowledge increases significantly. Thus, it was suggested that the "gaps in anatomical knowledge are filled by the time junior doctors become SHOs (senior house officers), especially if working in surgery or A & E [Accident and Emergency]" [7]. One might therefore expect that similar trends would be found among the junior physiotherapists as they progress through their clinical years.

While the attrition in anatomical knowledge detected in physiotherapy students tested at Curtin University were, therefore, to be expected, there may be some scope for implementation of strategies aimed at avoiding this attrition, which would lead to a better retention rate. Again, similar issues with attrition were noted in other programs. For example, in a comprehensive assessment of the retention rate, the third year medical students at The George Washington Medical School [5] were given anatomy tests covering different regions as they entered general surgery and obstetrics/gynaecology clerkships. The results were compared with the students' performance in their first year anatomy tests. The study revealed that the knowledge of surgical anatomy among the third year students was characterised by the significant attrition rate and was rather poor. The performance and retention varied considerably between different anatomical structures – from 12.8% (59.1% drop in retention rate) correct answers on esophageal varices to 97.2% (1.6% drop) on lymphatic drainage. The results of The George Washington Medical School study highlighted the need to improve students' retention and the necessity for the educational strategies which will facilitate this process to be based on a good assessment of students' current knowledge in various areas of anatomy [5].

The main features of strategies to improve retention of anatomy in medical education were the need to repeat and revise previously adopted knowledge, integrate this knowledge with that from other pre-clinical and clinical subjects and, perhaps most importantly, apply this knowledge within the clinical context [3,5,14,15]. Indeed, some of the educational paradigms such as 'Problem Based Learning' have been conceived to, among other advantages, facilitate integration and application of knowledge, starting at the early stages of study [16].

Some strategies to improve retention of anatomy have proven particularly valuable. At The Cleveland Clinic Learner College of Medicine of Case Western Reserve University these strategies were efficiently introduced within the so-called nesting approach [17,18]. This approach at Case Western Reserve characterised by intensive two half-day, cadaver-based revision sessions for the third year medical students. The nesting approach in anatomy was further developed at The George Washington University Medical School were it includes testing of students to assess their knowledge and area of weaknesses, together with combined e-modules and laboratory based revision sessions, both structured with a special reference to clinical anatomy.

We argue that the application of this and similar strategies should be highly profitable within the physiotherapy curricula. These approaches could now be applied easily and with little financial strain, following the recent advancements in anatomy education. Indeed, anatomy education has transformed rather dramatically in the last few decades as the old modes of teaching based on rote learning and adoption of excessive degree of anatomical detail (often irrelevant in clinical practice) evolved into more focused, clinically oriented and better integrated ways of delivery which favour deep learning [19,20]. Blended learning [21] in particular, could be successfully applied in this context as within this educational mode considerable amount of work is carried out on-line and at the convenience of both student and academics. The wealth of materials can now be presented to students on-line via different media (medical images, video recordings, interactive softwares, three-dimensional images, etc.), providing ample opportunities for quick and efficient testing, feedback and revision.

This study has some limitation. The carpal bone test is rather limited in its scope as it focuses on the osteology of a single anatomical region.

More comprehensive tests which would include a practical component based on cadavers, medical images and living anatomy as well as a battery of clinically oriented questions are needed for the full assessments of anatomy knowledge. We would also like to know more about student perceptions regarding their osteology education and experience, level of learning, satisfaction, or gained knowledge throughout their program. Furthermore, our sample of students was relatively small and only one institution was represented. Because of this our results must be seen as only preliminary, hopefully leading to more comprehensive tests at a number of different institutions.

## CONCLUSION

The physiotherapy students tested by the carpal bone test at Curtin University showed good knowledge of anatomy in their first year of study, while the final year students showed some attrition of anatomy knowledge. Strategies to improve retention rate in anatomy based on revision, integration and application of anatomical knowledge would be highly profitable in physiotherapy curricula. Future studies based on more comprehensive testing of bigger and more diverse sample of students are needed to throw more light on the issue of retention and to help devise strategies for its improvement.

**Conflicts of Interests: None**

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