# Bones at Home: Teaching and Learning Human Osteology through 'Living Room Labs'

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## INTRODUCTION

The shift to remote instruction due to COVID-19 led to pedagogical challenges in teaching human osteology laboratory courses. While readily available, previous bioanthropological research has found that virtual technologies (e.g., 3D digital models) are a "less reliable training tool" (Kuzminsky et al. 2019: 275). Students who learn from plastic models in anatomy are also found to perform significantly better than those who learn only from computer-based resources (e.g., Khot et al. 2013; Wainman et al. 2018, 2020). To address these concerns, **plastic skeleton models** were acquired by Mount Royal University (MRU) and the University of Manitoba (UofM) and each human osteology student took one complete human skeleton model home for the Winter Term (2021).

We report on the initial phase of a project that evaluates student learning of human osteology in non-traditional learning modes. We address how students educated remotely, using skeletal models, performed in the:

1. Recollection and identification of important **morphological features**
2. Application of **osteological techniques** (e.g., sex estimation)

Our results reflect on resources required for accessible and remote instruction, and will help educators to make informed (pandemic and post-pandemic) decisions about their laboratory resources and deliveries to maximize learning outcomes.

## METHODS

Replica skeletons were loaned to every human osteology student at MRU ($n$=30) and UofM ($n$=24). Each institution purchased different skeleton models: MRU from hBARSCI ($100-150 CAD each); UofM from Candent ($400-450 CAD each). UofM supplemented their full skeleton with disarticulated skulls from Candent ($250-300 CAD each).

After the course, students were invited to anonymously participate in a challenging survey that tested their knowledge using photos of real human bones in varying states of preservation/completeness. Participants were asked to identify the element, side, and/or morphological feature and to apply simple osteological methods for sex and/or age estimation (see Fig. 1 for an example question). Responses were scored as correct or incorrect; a strict approach was adopted so that only completely correct answers earned a point. For example, an image depicting a first metatarsal that asked for a specific bone identification only earned a point for the answer 'first metatarsal'. Results were compared between course institutions.

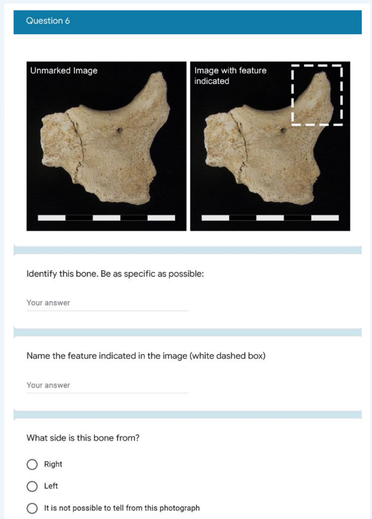
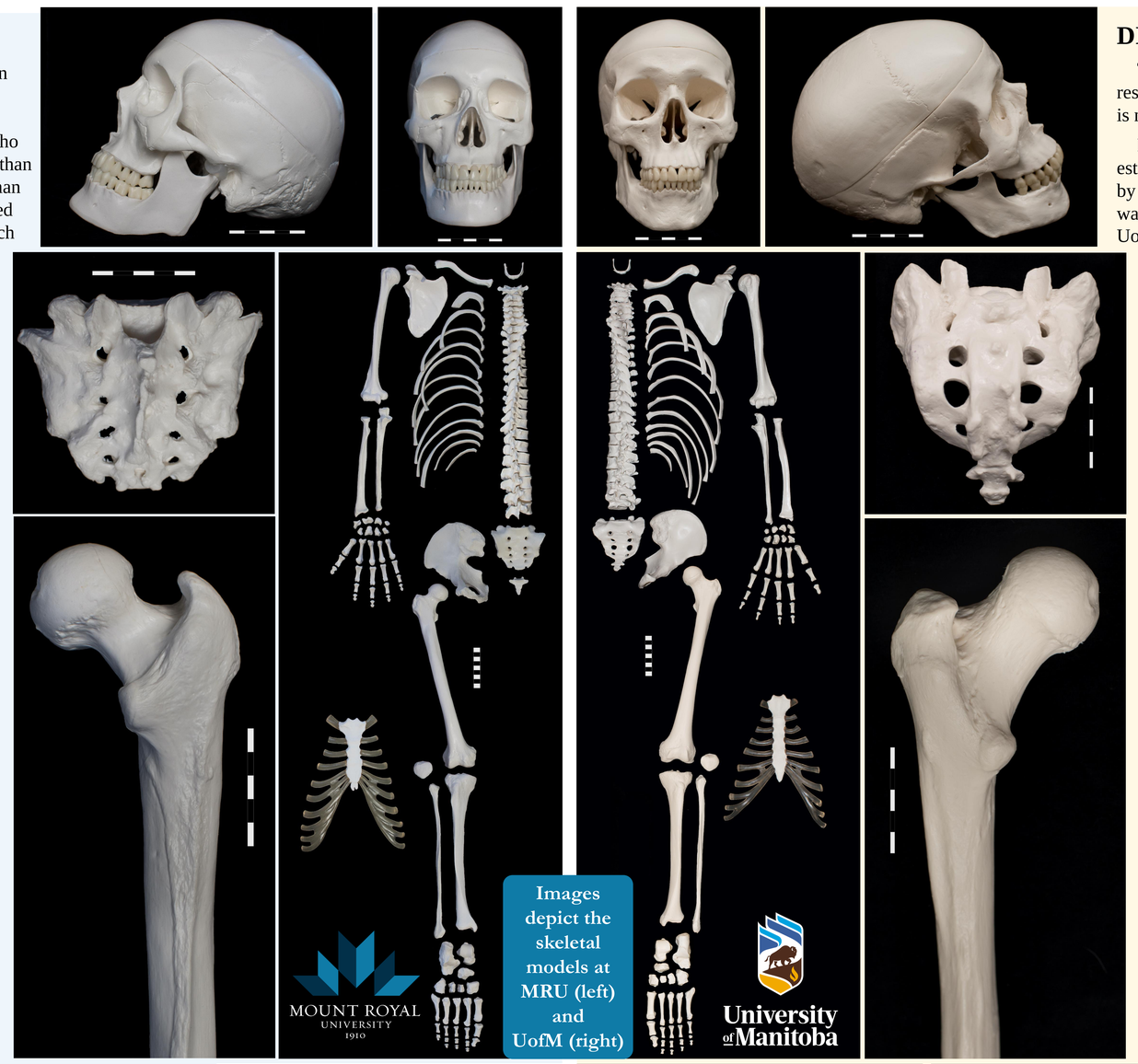



Figure 1: Example question from the osteological survey

## RESULTS

Fourteen respondents who took Human Osteology remotely in Winter 2021 completed the questionnaire (MRU $n$= 8/30; UofM $n$=6/24); one individual (the 15th response) was excluded as an outlier whose results fell outside (lower), two standard deviations, from the mean. Results showed poor correspondence between average perceived and actual osteological skill ($r_s(12)$=.392, p=.166), suggesting participants are likely to over- or under-estimate their abilities (Fig. 2).

Overall, participants scored an average of 54.5% (see MRU & UofM specific results Table 1, 2, 3, Fig 3.). With the exception of age-estimation scores, MRU and UofM scores did not significantly differ across body region, skill, or image type. Participants struggled most with questions involving age estimation (40%) and images depicting fragmentary or in situ remains (37.5%). Low scores are also reported for the upper limb (35.4%), but these results can be explained by a higher proportion of fragmentary and in-situ images used to examine this body region (image types that already proved challenging for participants).



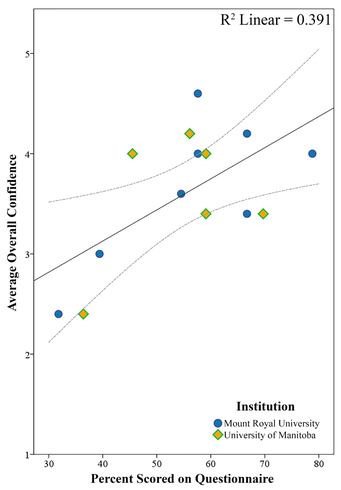




Figure 2: Relationship between perceived skill (confidence) and total questionnaire score (%).

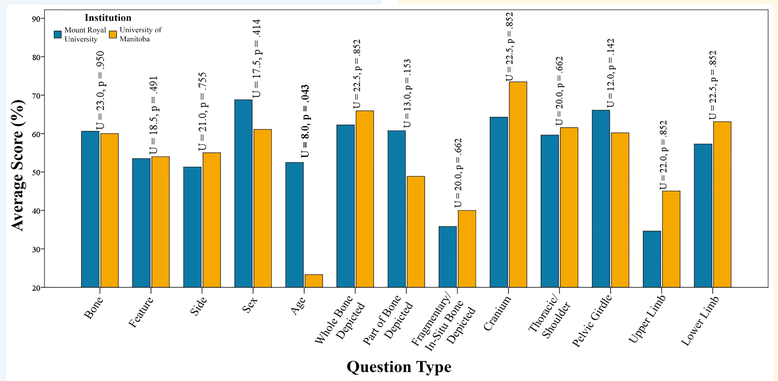



Figure 3: Comparison of mean scores at MRU & UofM by question type.

Tables 1, 2, 3: Average scores/percentages for each question type by institution.

| 1. Question Type | Total | | Mount Royal University (MRU) | | University of Manitoba (UofM) | | Mann Whitney U test statistics |
|---|---|---|---|---|---|---|---|
| | Confidence* | Score | Confidence* | Score | Confidence* | Score | |
| Bone Identification | 4.1 | 60.5%<br>12.1/20 | 4.4 | 60.5%<br>12.1/20 | 3.8 | 60.0%<br>12/20 | U = 23.0,<br>p = .950 |
| Morphological Feature Identification | 3.8 | 53.6%<br>13.4/25 | 3.6 | 53.6%<br>13.4/25 | 4.0 | 54.0%<br>13.5/25 | U = 18.5,<br>p = .491 |
| Side Identification | 3.4 | 53.0%<br>5.3/10 | 3.1 | 51.0%<br>5.1/10 | 3.8 | 55.0%<br>5.5/10 | U = 21.0,<br>p = .755 |
| Sex Estimation | 3.6 | 65.0%<br>3.9/6 | 3.8 | 68.3%<br>4.1/6 | 3.3 | 61.7%<br>3.7/6 | U = 17.5,<br>p = .414 |
| Age Estimation | 3.1 | 40.0%<br>2.0/5 | 3.4 | 52.0%<br>2.6/5 | 2.8 | 24.0%<br>1.2/5 | **U = 8.0,**<br>**p = .043** |
| Total | 3.6 | 54.5%<br>36/66 | 3.7 | 56.7%<br>37.4/66 | 3.6 | 54.2%<br>35.8/66 | U = 23.0,<br>p = .950 |

* Confidence ranked on scale of 1-5 (1=not confident; 5=extremely confident). Bold font indicates statistical significance ($p \leq .05$).

| 2. Body Region | Total | Mount Royal University (MRU) | University of Manitoba (UofM) | Mann Whitney U test statistics |
|---|---|---|---|---|
| Cranium | 66.4%<br>9.3/14 | 64.3%<br>9.0/14 | 69.3%<br>9.7/14 | U = 22.5,<br>p = .852 |
| Thoracic & Shoulder Region | 57.7%<br>7.5/13 | 60.0%<br>7.8/13 | 55.4%<br>7.2/13 | U = 20.0,<br>p = .662 |
| Pelvic Region | 60.7%<br>8.5/14 | 66.4%<br>9.3/14 | 53.6%<br>7.5/14 | U = 12.0,<br>p = .142 |
| Upper Limb | 35.4%<br>4.6/13 | 34.6%<br>4.5/13 | 36.2%<br>4.7/13 | U = 22.0,<br>p = .852 |
| Lower Limb | 57.5%<br>6.9/12 | 57.5%<br>6.9/12 | 56.7%<br>6.8/12 | U = 22.5,<br>p = .852 |

| 3. Bone 'Completeness' | Total | Mount Royal University (MRU) | University of Manitoba (UofM) | Mann Whitney U test statistics |
|---|---|---|---|---|
| Whole Bone Depicted | 63.7%<br>17.2/27 | 62.2%<br>16.8/27 | 65.9%<br>17.8/27 | U = 22.5,<br>p = .852 |
| Only a Part of Bone Depicted | 55.6%<br>15.0/27 | 60.7%<br>16.4/27 | 48.9%<br>13.2/27 | U = 13.0,<br>p = .153 |
| Fragmentary/ In-Situ Bone Depicted | 37.5%<br>4.5/12 | 35.8%<br>4.3/12 | 40.0%<br>4.8/12 | U = 20.0,<br>p = 662 |

## DISCUSSION

This preliminary study illuminates potential areas for effective laboratory resource expansion while also showing that remote osteological instruction is not without limitations.

Participant scores were consistent between MRU and UofM. Only age estimation skills were found to significantly differ, which can be explained by institutional/instructor course design differences Specifically, more time was dedicated to instructing age-estimation techniques at MRU than at UofM (see Table 4 for further course comparisons), resulting in UofM students having less exposure to these techniques and consequently lower scores. Age-estimation aside, the similarities in skills demonstrated by remotely-educated undergraduates suggests that they attained similar levels of practical skeletal knowledge, regardless of the type, brand, or expense of at-home resources they were supplied with. This finding has implications for educators wishing to expand their laboratory resources. At this level of education, budget models are sufficient to achieve comparable student osteological skill-acquisition.

Table 4: Summary of differences/similarities in the offerings of Human Osteology at MRU and UofM.

| Course Comparisons | Mount Royal University (MRU) | University of Manitoba (UofM) |
|---|---|---|
| **Take-Home Resources** | 1 x hBARSCI disarticulated skeleton | 1 x 3B Scientific disarticulated skeleton<br>1 x 3B Scientific disarticulated skull<br>*Both items via Candent* |
| **Contact Hours** | 1 hour 20 min lecture<br>1 hour 20 min lab | 2 hour 45 min lecture + lab (single session) |
| **Additional Resources** | Lab Instructor<br>(teaches 1 hour 20 min lab unit) | |
| **Other Notes on Course Design** | One week spent on sex estimation<br>One week spent on age estimation | One week dedicated to pelvic girdle features, sex, *and* age estimation |

The overall scores were low (54.5% on average). This is partly due to the challenging test design needed to ensure that those with more significant knowledge could still be identified and compared. Students struggled the most with applying their skills to images of incomplete or in situ remains, answering on average only 37.5% of these questions correctly. We also observed difficulty in applying age-estimation techniques. Although take-home models may prove useful in learning bone and feature identification, they are limited in their capacity to familiarize students with incomplete remains and with the range of human variation needed to establish a biological profile.

## CONCLUSION

These results will help inform decisions about laboratory resources and deliveries required for effective pedagogy, but also enforce the indispensable nature of in-person laboratory education. The similarities in participant scores between MRU and UofM suggests that the expense and detail of take-home model resources has little effect on a learner's ability to acquire human osteology skills. Budget options can be sufficient for at-home learning, but in ideal situations these resources should represent a range of individuals and levels of preservation.

Beyond COVID-19 remote teaching, take-home skeleton models represent an adaptive approach to human osteological teaching techniques and an improvement to accessibility in osteological laboratories. They have the potential to allow for more diverse and equitable offerings of laboratory-based courses, potentially improving student learning outcomes, driving educator decisions, and also building suitable approaches to universal design in our field.

## ETHICS

Study approved by the Human Research Ethics Boards at MRU (#102482) and UofM (#R2-2021:043 [HS24870]).

## WE NEED YOU!

**Are you a grad student, faculty member, and/or employed in the professional sector with experience in human osteology?**

We are expanding this study to compare our test responses with human osteology experts (and students taught in-person at MRU & UofM).

Scan this QR code to read more and complete our lab-exam style questionnaire. You can also leave a business card/contact email in the envelope and we will follow up.

## ACKNOWLEDGEMENTS

Our sincere thanks go to the Winter Term 2021 Human Osteology students at MRU and UofM who participated in this research. You are helping to improve osteological education approaches for future learners and we appreciate your help. RJG also thanks the MRU Arts Faculty Endeavour Fund who granted the funding needed to purchase these skeleton kits and the MRU Library who graciously distributed the kits to students. JAG extends her thanks to the UofM Faculty of Arts who funded her skeleton models and Dr. Rachel ten Bruggencate (UofM) who assisted with model acquisition and distribution.

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