A comparison of operative autonomy between men and women in orthopaedic surgical training in Aotearoa New Zealand

Elizabeth C Bond, Frances H Whiting, Peter D Larsen, Georgina Chan

ABSTRACT

AIM: Recent studies have shown that women training in surgical and procedural specialties achieve less operative autonomy during training than men do. The aim of this study was to discern if there is a disparity in surgical autonomy for orthopaedic trainees by gender.

METHODS: This was a retrospective study of operative procedures performed by 53 orthopaedic trainees (43 men, 10 women) in Aotearoa New Zealand over 10 years. The main outcome measure was the amount of surgical autonomy afforded to individual trainees as recorded in the training logbook, categorised as assisting a: primary surgeon with consultant scrubbed or present; or, primary surgeon unsupervised and teaching a colleague the procedure.

RESULTS: Data was obtained for 41,622 procedures in total. Eighty point seven percent were performed by men and 19.3% by women. On average men performed 229 cases per year and women performed 251 cases per year. There was an overall significant difference in autonomy between men and women (p <0.001), with men performing more procedures unsupervised than women (45% of all cases versus 39% of all cases). This difference remained significant when trainee year group was accounted for.

CONCLUSIONS: We conclude that women orthopaedic trainees in Aotearoa New Zealand perform fewer cases with meaningful autonomy than men. This disparity may have implications for the quality of training received by men versus women.

Achieving operative autonomy is essential for surgical trainees to progress their skills and become confident and competent consultants.[1] Exposure to a wide range of trauma and elective cases during training enables the development of autonomy. This should be equal irrespective of gender or other demographics. Currently the Aotearoa New Zealand orthopaedic training scheme, administered by the New Zealand Orthopaedic Association (NZOA) under the jurisdiction of the Royal Australasian College of Surgeons (RACS), has 24.2% women trainees, compared to 5.4% 10 years ago. Six percent of consultant orthopaedic surgeons in Aotearoa New Zealand are women.[2] This increasing diversity, in a specialty that tends to have the lowest rates of women world-wide,[3] should be celebrated. It is well established that there are significant positives to having women in leadership roles,[4,5,6] and women surgeons have been shown to have equal or better short-term outcomes post-operatively.[7,8]

However, recent studies have shown that women in surgical and procedural specialties achieve less operative autonomy during training than men. In Aotearoa New Zealand, women general surgery trainees performed significantly fewer operative cases independently,[9] and women ophthalmology trainees completed almost 41% fewer independent cataract cases by the end of their training.[10] This finding has potentially significant repercussions for the quality of training received by women.

Our study aimed to identify differences in operative autonomy between women and men in orthopaedic surgical training in Aotearoa New Zealand. We also performed a scenario-based survey asking trainees to rate operative autonomy, to explore if any difference could be subjective.

Methods

Logbook data

This was a retrospective longitudinal cohort study. Informed consent was sought from all NZOA trainees over a total of 10 years (2011–2020 inclusive) for the use of their data. There was a total of 96 trainees during this time, consisting of 82 men and 14 women. Data for all 53 consenting trainees (overall response rate 55%; 43 men (52%) and 10 women (71%)) were retrieved from two

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logbook databases: MALT (Morbidity Audit and Logbook Tool) and TIMS (Training Information Management System). The MALT logbook was a RACS-mandated tool used by all trainees until the new TIMS logbook administered by NZOA was phased in in 2019. There was no duplication of data between the two logbooks. All retrieved data were de-identified. The study was exempt from ethics approval, as per the Health and Disability Ethics Committee of Aotearoa New Zealand criteria.

Data retrieved for each operative procedure included trainee gender (man or woman), hospital type (secondary or tertiary), year the procedure was performed, Surgical Education and Training (SET) level at time of procedure (Year 1–5), type of procedure (trauma or elective), free text noting the description of the procedure and level of autonomy. Datasets were all complete except for the "hospital type" data from the MALT logbook. Key procedures were assessed as a subgroup analysis. Primary total arthroplasty procedures (combined total hip and total knee replacements, due to log book coding as "arthroplasty: primary, total") were assessed.

Autonomy level was ranked as 1 (assisting the primary surgeon), 2 (performing the procedure supervised), 3 (performing the procedure unsupervised) or 4 (teaching a colleague the procedure). These data were recorded and saved after each procedure by the trainee. The logbook is reviewed by the trainee supervisor four times per year, although there is no formal system for entries to be approved by the supervising surgeon. No demographic data regarding the responsible consultant surgeon was collected.

The NZOA/RACS training scheme is 5 years in duration (SET 1–5) and trainees are distributed between 17 training hospitals. Data regarding trainees who took time out of the programme during the study period were also collected. Placements are decided by trainee ballot on an annual basis. The majority of SET 4 and SET 5 trainees work in tertiary centres in preparation for their final exams.

Survey responses

The survey was distributed to all current trainees (for the 2020 training year) using the Survey Monkey platform (Momentive, San Mateo, California): a total of 60 trainees (49 men, 11 women). Twenty-eight of 60 current trainees completed the survey (response rate 47%) (21 men, 7 women). Respondents were asked to complete demographic data including gender, SET level, type of hospital (secondary or tertiary), case numbers achieved and number of years working as an orthopaedic registrar (recorded separately to SET level, as registrars work for variable amounts of time prior to being selected for training). They were asked to respond to a scenario assessing self-evaluation of autonomy. All five scenarios were prefaced with the question "*Would you consider yourself the primary/lead surgeon for logbook purposes in the following scenario?*" Answers were a binary choice between yes and no (Appendix 1: survey scenarios/questions).

Statistical analysis

All data were analysed using SPSS 27 (IBM, New York). Data are presented as a percentage. Categorical variables were compared using Chi-squared tests. A multinomial logistic regression was used to analyse the relationship between gender, SET level and trauma vs elective related surgery. Hospital type was not included in this model due to missing data. A p-value <0.05 was considered statistically significant. For the survey response data, statistical power was limited by the small sample size. Data were treated as categorical variables and analysed using Chi-squared tests.

Results

The logbook dataset included 53 trainees in total; 43 men (81%) and 10 women (19%). The gender balance changed over time, with only 5.4% women trainees in 2011 and 18.3% in 2020. Data were available for a total equivalent to 179 training years; 147 (82%) men training years and 32 (17.8%) women training years. Overall, there were data for 41,622 cases, with all procedures performed over a 10-year period (2011 to 2020 inclusive). Overall, men performed 33,593 (80.7%) of the cases, and women performed 8,029 (19.3%). Women trainees averaged 251 cases per year and men trainees averaged 229 cases per year. Two women had two 6-month interruptions and another three women had one 6-month interruption during the study period, for parental leave. One man had a 12-month interruption for research. They did not input data into the logbook system during their time out and returned to the same SET level as when they began their interruption. Time taken out from training was required to be made up, so total training time remained at 5 years; however, the interruptions may have resulted in some data from these trainees being recorded after the completion of data collection.

Overall autonomy

There was a statistically significant difference in level of autonomy between men and women overall ($p<0.001$). Table 1 shows cases by autonomy level. Taking all training years into account, case numbers were equal at autonomy level 2 (primary surgeon supervised) and 4 (teaching a colleague). Women performed more cases at autonomy level 1 (assistant surgeon) than men. Men performed more cases at level 3 (primary surgeon unsupervised) than women. Figure 1 shows the distribution across autonomy levels of cases that all trainees completed. There was a progressive increase in the number of level 4 cases (teaching a colleague) and decrease in the number of cases at level 1 (assistant) as the SET level increased.

Autonomy by training year

This statistically significant difference remained when data were divided into training years. Every year demonstrated a similar pattern, with women performing more cases at autonomy level 1 and level 2, and men performing more cases at autonomy level 3 and level 4. The only exception was women in the SET 4 year performing more cases at level 3. Table 2 shows data for each training year. Figure 2 shows the proportion of cases completed at level 1 by gender and year level. Figure 3 shows the proportion of cases completed at level 3 by gender and year level.

Multinomial logistic regression modelling showed that after correction for SET level and trauma surgery, odds ratios for men trainees operating at levels 2, 3 and 4 compared to women trainees were 1.29 (95% CI 1.21–1.38), 1.72 (1.60–1.84) and 1.93 (1.61–2.34) respectively.

Changes over time

Examining the first 5 years of the dataset (2011–2015) against the last 5 years of the dataset (2016–2020) in a multinomial logistic regression, trainee autonomy levels were significantly influenced by gender ($p<0.001$) and SET level ($p<0.001$) but not by time period ($p=0.41$).

Trauma versus elective

Of the cases, 24,490 (58.8%) were trauma and 17,132 (41.2%) were elective. There was no significant statistical difference in the proportion of trauma versus elective cases between men and women, with each performing 59% of their cases as trauma cases ($p=0.4$). There was a significant difference in autonomy level between elective and trauma cases overall ($p<0.001$) (Table 3).

Secondary versus tertiary hospital

Data for hospital type were incomplete, with missing data for 24,892 cases. Of the available data, 8,181 cases were performed in a secondary hospital and 8,556 in a tertiary hospital. Men performed more of their cases at a tertiary hospital (54%) than women (39%) ($p<0.001$). Figure 4 shows cases divided by autonomy level between secondary and tertiary hospitals. More unsupervised cases were performed in secondary hospitals compared to tertiary ($p<0.001$).

Key procedures: primary total hip and knee arthroplasty

4,876 total hip and knee arthroplasty cases were recorded: 3,879 performed by men and 997 performed by women. Another 2,319 (47.6%) were performed at level 1, with 45% of cases done by men and 57% of cases done by women. A further 2,417 (49.6%) were performed at level 2, with 52% for men and 41% for women. One hundred and thirty-nine (2.9%) cases were performed at level 3; 3% for men and 2% for women. One case was recorded at level 4.

In a multinomial logistic regression model, there was a statistically significant difference in trainee autonomy levels by gender ($p<0.001$) and SET level ($p<0.001$). SET 5 women performed 53% of these operations at level 1, compared to men in 42% of cases. Women performed 35% of operations at level 2 compared to 53% in men. Statistical differences in autonomy levels were observed at every level of training. Figure 5 depicts these differences.

Survey data

Twenty-eight of 60 current trainees completed the survey (response rate 47%). Of the respondents, 20 (71%) were men and 7 (24%) were women; one respondent did not state their gender. Fifteen trainees (54%) were in tertiary centres and 13 (46%) were in secondary centres. Seven (24%) were SET 1, 11 (39%) were SET 2, three (11%) were SET 3, two (7%) were SET 4 and four (15%) were SET 5. One (4%) respondent did not give their SET level. Three scenarios showed high concordance between all trainees (scenario 1, 3 and 5), whereas two scenarios (scenario 2 and 4) demonstrated a more mixed response. No statistical relationship was found between the answer and the variables of gender, training year or hospital type. Complete survey answers are provided in Appendix 2.

Discussion

Our study demonstrates a significant difference in operative autonomy between women and men in orthopaedic training in Aotearoa New Zealand. In every training year, women performed fewer cases at higher autonomy levels, despite performing a higher number of cases annually. We don't have a definitive explanation for the higher volume of procedures performed by women, but one potential reason is that case complexity is not accounted for in the data. Women may have been performing cases of lower complexity or shorter duration compared with the men: one trainee may have performed four ankle open reduction internal fixations (ORIFs) compared to another who did one hip revision for periprosthetic fracture on a given trauma day. Another finding was that trainees have significantly less supervision in secondary hospitals than tertiary ones. There were more women trainees in secondary centres, so even in a more unsupervised environment, women were still not afforded comparable levels of autonomy to men. The differences in autonomy also remain

Table 1: Cases by autonomy level.

Service contribution	Men	Women
Assistant surgeon 1	8,957 (27%)	**2,658 (33%)**
Primary surgeon supervised 2	9,323 (28%)	2,279 (28%)
Primary surgeon unsupervised 3	**14,486 (43%)**	2,936 (37%)
Teaching a colleague 4	832 (2%)	157 (2%)

Figure 1: Autonomy level of cases completed by all trainees according to SET level.

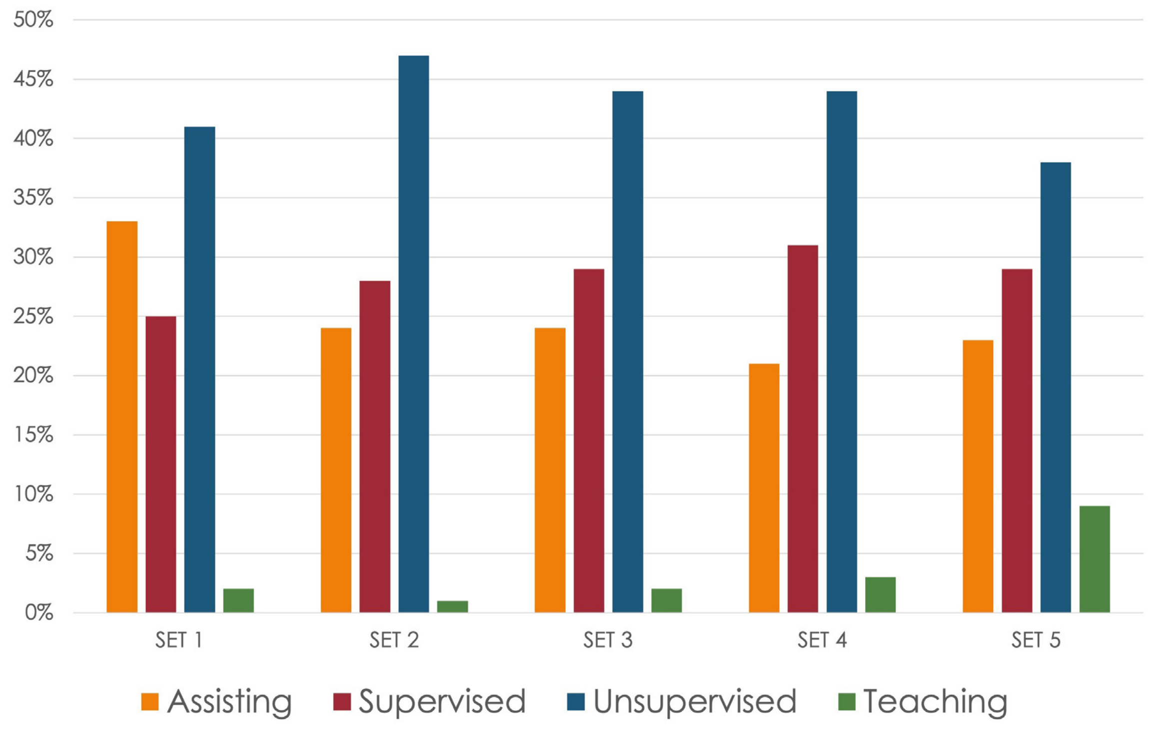


Table 2: Data by training year.

SET 1		
Autonomy level	Men	Women
1	3,922(33%)	**902 (39%)**
2	**2,990 (25%)**	505 (22%)
3	**4,898 (41%)**	883 (38%)
4	215 (2%)	29 (1%)
SET 2		
Autonomy level	Men	Women
1	1,817 (24%)	**946 (34%)**
2	2,176 (28%)	**828 (30%)**
3	**3,625 (47%)**	935 (34%)
4	92 (1%)	**54 (2%)**
SET 3		
Autonomy level	Men	Women
1	1,730 (24%)	**388 (25%)**
2	2,114 (29%)	**560 (36%)**
3	**3,153 (44%)**	604 (38%)
4	**143 (2%)**	20 (1%)
SET 4		
Autonomy level	Men	Women
1	789 (21%)	**121 (30%)**
2	**1,164 (31%)**	91 (23%)
3	1,653 (44%)	**189 (47%)**
4	**127 (3%)**	0 (0%)
SET 5		
Autonomy level	Men	Women
1	699 (23%)	**301 (31%)**
2	879 (29%)	**295 (30%)**
3	**1,157 (38%)**	325 (33%)
4	**255 (9%)**	54 (6%)

Figure 2: Proportion of cases performed by men and women trainees as assistant surgeons.

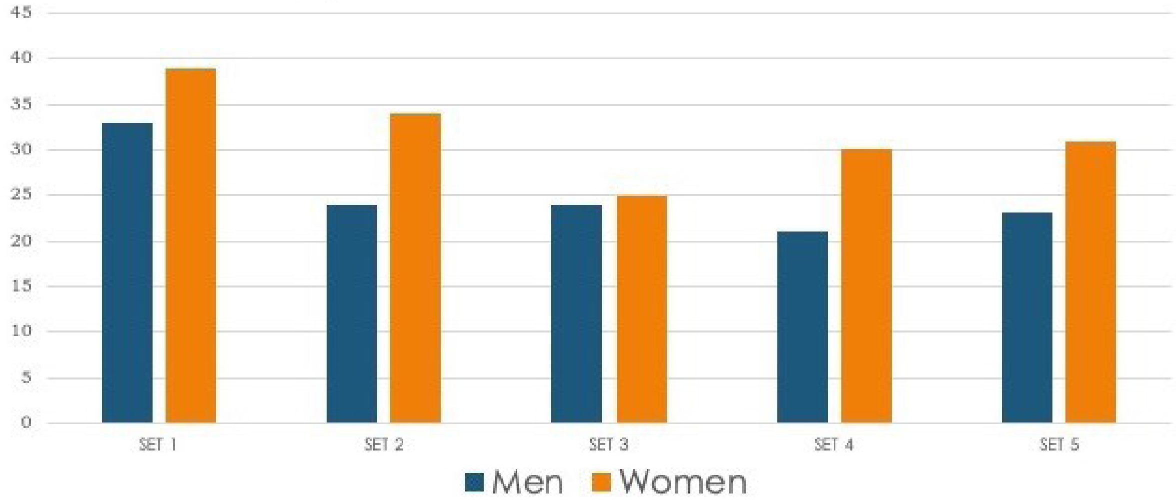


Figure 3: Proportion of cases performed by men and women trainees unsupervised.

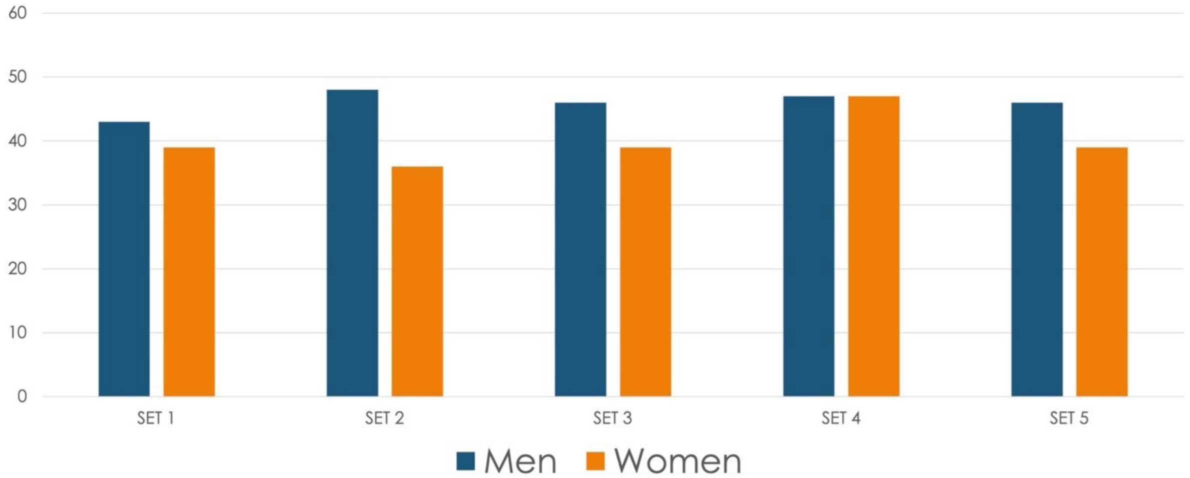


Table 3: Overall autonomy level between trauma and elective cases.

Autonomy level	Trauma	Elective
1	3,410 (14%)	**8,201 (48%)**
2	5,283 (22%)	**6,317 (36%)**
3	**14,846 (61%)**	2,576 (15%)
4	**951 (4%)**	38 (0.2%)

Figure 4: Autonomy level by hospital type.

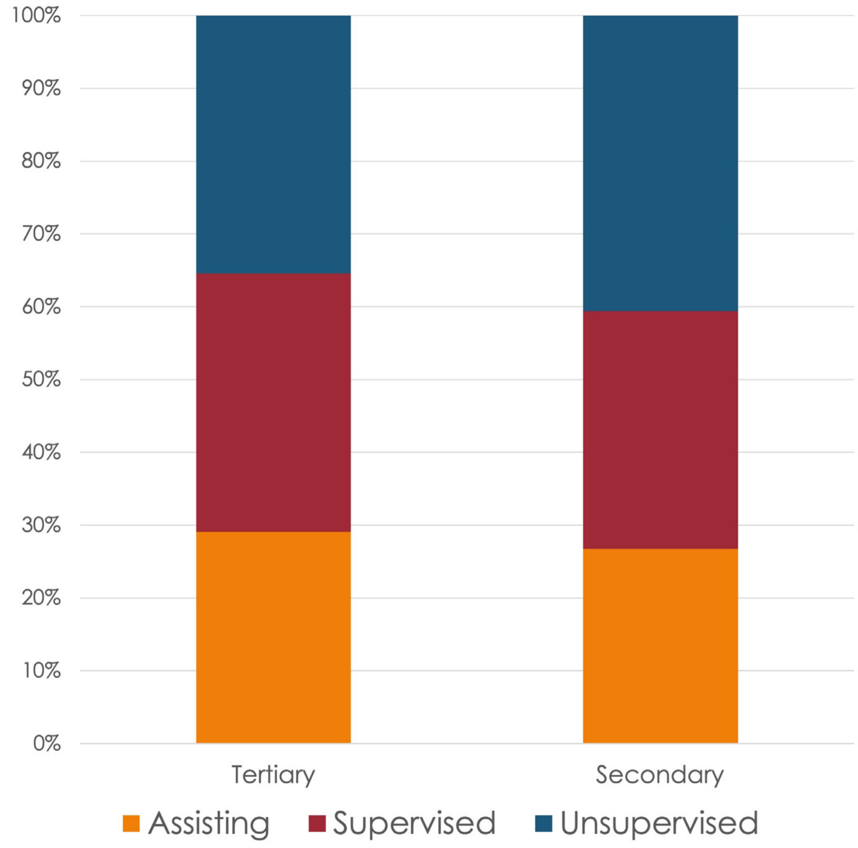
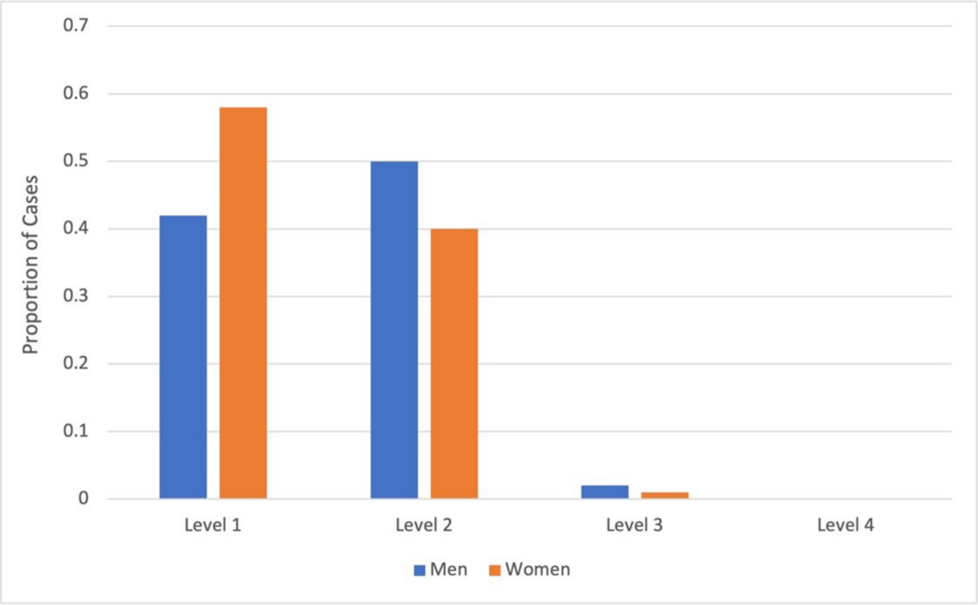


Figure 5: Autonomy for key procedures: primary total hip and knee arthroplasty.



apparent when looking specifically at core procedures—hip and knee arthroplasty.

The results are consistent with those of two other retrospective logbook data studies performed in Aotearoa New Zealand. A 2020 study found that women in general surgery training performed fewer cases as the primary surgeon with the consultant available but unscrubbed than men.[9] A 2021 review of ophthalmology trainees found that women performed fewer cases per year than men (21.1% fewer by the fourth year), and 41.7% fewer autonomous cataract cases by the end of training.[10] In a similar United States (US) logbook study, women general surgery residents received less operative autonomy than men, who progressed more rapidly.[11]

Overall, the results support the emerging objective evidence demonstrating a phenomenon of women achieving lower levels of operative autonomy in procedural specialties, persisting throughout training. The findings raise two main questions—why does this difference exist, and what is the impact? There is widespread evidence that women underrate and underestimate their own abilities in many professional fields including surgery,[12,13] which is likely to affect how women advocate for their autonomy. In a retrospective review, US women orthopaedic residents consistently gave themselves scores that were lower than their faculty evaluations, whereas men tended to rate themselves at the same level or even above the level their faculty had rated them.[14] Two other studies show women scoring themselves lower than men.[15,16] We attempted to objectively assess this with a scenario-based survey to see if the differences could be attributed to men and women rating autonomy differently. Statistical analysis did not demonstrate any significant discordance, but this was limited by small sample size. In addition, societal pressures influence women's behaviour, with pervasive cultural norms dictating that assertiveness and competitiveness are favourable traits in men.[17,18,19,20] These factors can add up to an outward appearance of low "confidence", which is still used a barometer of ability.

Men and women also have different learning styles. Evidence from the domains of finance and sports suggest that women "*find negative feedback more aversive and make them more inclined to doubt their abilities*".[12] A systematic review concluded that men and women differed in their development of surgical skills and their responses to different training methods, with women preferring mentorship and one-on-one instructor feedback.[21] Implicit bias (an unconscious underrating of women persisting despite one's conscious beliefs[24]) still exists. Studies show a perception from supervisors of more intra-operative guidance being required for women than men;[22] and giving men significantly more autonomy than women with all other factors controlled for.[11,16] Social experiments have shown that both genders are susceptible to implicit bias, with women perceived as being less competent by both women and men.[23]

Should we therefore change our training methodology to optimise the experience and outcome of orthopaedic training for women? A 2019 article stated that "*we should be mindful of psychological differences between genders, including in confidence and self-assessment*" [24], while Ali et al. concluded that the surgical training of women should include more mentorship and feedback, and that "*gender issues should be considered when designing surgical training to better accommodate the needs of future surgeons*".[21]

The second question regarding the impact of this difference led us to consider the value of operative autonomy during training. The optimal timeline to operative autonomy has not been defined in any specialty and likely differs between individuals. It is possible that increased supervision would lead to an increase in teaching moments and therefore faster attainment of surgical skills. The existence of an autonomy gap at the end of training is a concern,[22] as it might seem disadvantageous for women to have significantly less autonomous operating experience. However, studies that have compared the outcomes of men and women surgeons have found that women actually tend to have better results,[7,8] despite this discrepancy. This may indicate that achieving high levels of autonomy during training is not as crucial as may be imagined, and that supervised operating may confer more benefits. Anecdotally, there is an international trend towards more consultant involvement and supervision. New Zealand is fairly unique in that significant case numbers are still performed unsupervised; however, these changes are likely to affect trainee autonomy here going forward. We consider a 10-year period an appropriate length of time for this study, but there were only 5.4% women trainees at the beginning. It would be worthwhile considering a repeat analysis in a few years to capture the experiences of the current 24% women trainee cohort.

The impact of the autonomy gap on trainee surgeons is unknown, but it indicates an underlying inequality between men and women throughout training. The increase in diversity and number of women selected for orthopaedic training in Aotearoa New Zealand should be celebrated. However, the format and nature of the training scheme remains unchanged. We should use increasing diversity as an opportunity to develop and enhance our surgical training. As the number of women orthopaedic consultants grows, this will inherently improve mentorship, women leadership and role modelling. Formalisation of personal coaching and mentorship outside of the operating room will help trainees with personal growth. We should remain responsive to trainees and accommodate their learning needs while being clear on overall learning objectives. Leadership training could be incorporated into the curriculum, allowing trainees and supervisors alike to gain insight into how people respond to criticism and organisational culture. Supervisors need to be mindful of the necessary communication styles that result in the optimal improvement from their trainees and acknowledge that this will differ between individuals regardless of gender. Making a conscious effort to network and socialise with peers enables discussion of common issues, and groups such as Ladies in Orthopaedics New Zealand (LIONZ) provide a formal pathway for communicating the needs of a minority.

Limitations of this study include all data being self-reported and open to subjective bias. Although we performed an objective survey to account for this, sample size was small (due to a lack of trainees opting in) and from a different population of trainees. The dataset included 55% of all possible trainees but, of note, data were included for 71% of women over this time. We had missing data for hospital type, although still had sufficient data for analysis. We did not collect data concerning experience of trainees prior to training, which may have an impact on time taken to achieve autonomy. With regards to trainees taking time out, ultimately, they do complete 5 years of training. We anticipate that an interruption to training could result in some of that trainees' logbook data being entered outside of the study period and therefore not included in this study. We do not think that it would otherwise affect the results, as training level and surgical skill level are unchanged. Similarly, Gill et al. did not find any statistical association between interrupted training and performance of independent cases.[5]

Conclusion

Our study adds to a growing body of objective evidence that there is a difference in the experience of surgical training according to gender. Women experience less meaningful operative autonomy than men at all year levels during orthopaedic training. As diversity increases in surgical training, we must identify different learning styles and account for this in the design of our surgical training programmes by accommodating individual trainees in order to optimise their personal and professional development.

COMPETING INTERESTS
Nil.

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Appendix 1: survey scenarios/questions

All five scenarios were prefaced with the question "*Would you consider yourself the primary/lead surgeon for logbook purposes in the following scenario*?"

Scenario One: "*You begin a total hip replacement but have difficulty with the acetabular component and the consultant needs to take over and complete the case?*"

Scenario Two: "*You are performing a total hip replacement and require assistance from the consultant to ream and impact the acetabular component but once this is done you complete the femoral side and finish the rest of the operation?*"

Scenarios Three: "*You are fixing a complex tibial plateau fracture with the consultant scrubbed; you do the lateral side, and they do the medial side?*"

Scenario Four: "*You scope a knee and perform a partial meniscectomy—once you are done the consultant looks around the joint and tidies up the meniscal rim?*"

Scenario Five: "*You are teaching a junior how to ORIF a Weber B ankle fracture; you are scrubbed with them, help them do the approach. You need to reduce the fracture and help aim the drill for all screws?*"

Appendix 2: survey responses

	Men	Women	Total	Concordance
Respondents	**20**	**7**	**27** **1 no response**	
SET level				
1 2 3 4 5	5 8 2 2 3	2 3 1 0 1	7 11 3 2 4 1 no reponse	
Years as orthopaedic registrar	Mean 5.6 Median 5 Range 2–10	Mean 5.3 Median 5 Range 3–7	Mean 5.5 Median 5 Range 2–10	
Scenario 1	Yes 4 No 16	Yes 0 No 7	Yes 4 No 23	High
Scenario 2	Yes 18 No 2	Yes 6 No 1	Yes 24 No 3	High
Scenario 3	Yes 12 No 8	Yes 2 No 5	Yes 14 No 13	Low/mixed responses
Scenario 4	Yes 0 No 20	Yes 0 No 7	Yes 0 No 27	High
Scenario 5	Yes 10 No 10	Yes 6 No 1	Yes 16 No 11	Low/mixed responses