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## Background and Importance

Manual compounding of sterile preparations may involve repeated manipulations and physical force, particularly during syringe withdrawal and injection, which could contribute to repetitive stress injuries. Measuring these forces may provide objective evidence of the process's physical demands.

## Aim and Objectives

▶ To identify the most ergonomically demanding manual preparations by measuring withdrawal and dilution forces, supporting prioritization for robotic compounding.

## Materials and Methods

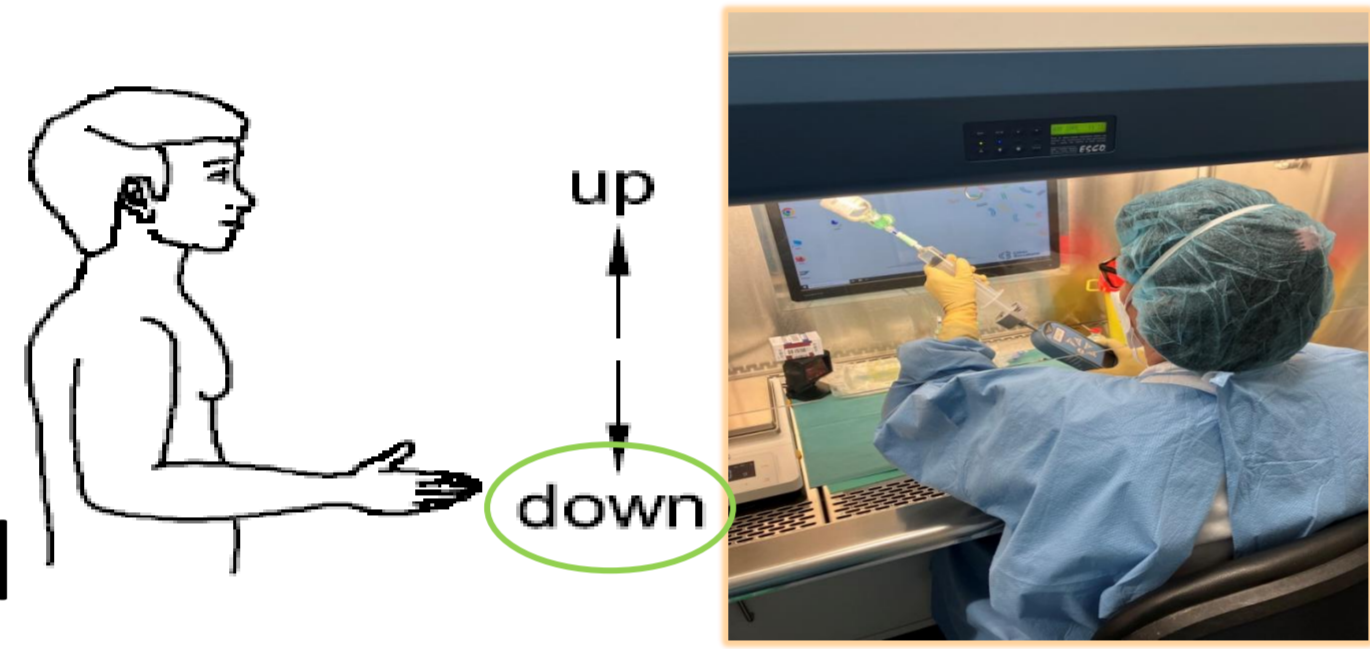
The study was conducted in three hospitals combining manual and automated compounding with the Kiro Oncology<sup>®</sup> robot.

- Preparations were selected by drug, dose, density and final container. Additional laboratory tests were conducted using normal serum (NS), water for injection (WFI), and 5% dextrose (D5W) with syringes from 1 to 50mL, to assess force across sizes and solutions.

- Two manual movements were assessed:

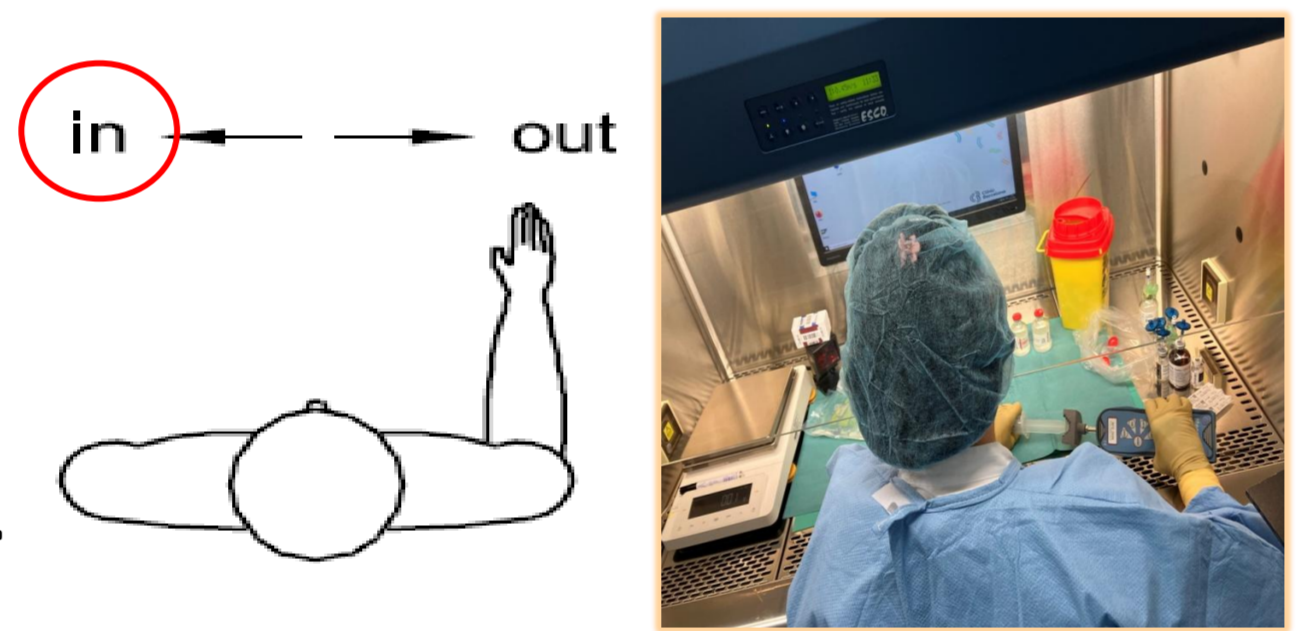
### Withdrawal

pulling the syringe plunger to aspirate the drug from the vial

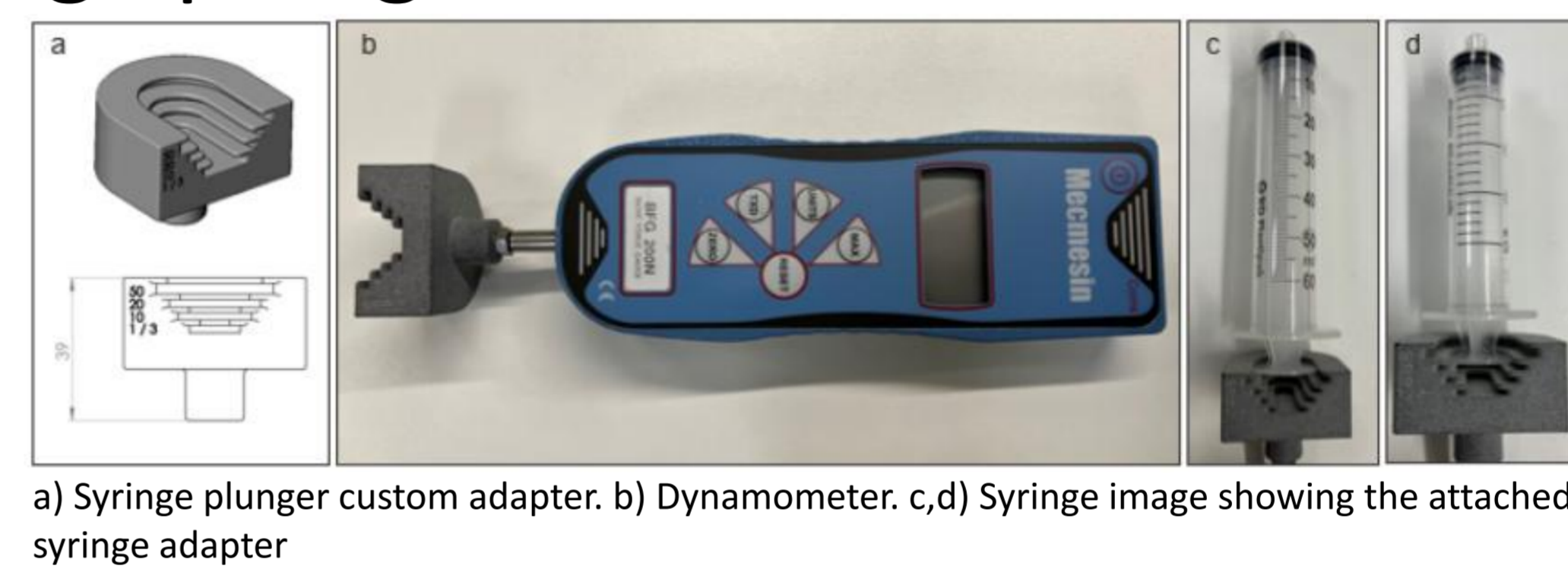


### Insertion

pushing the plunger to transfer the solution into the final container



- A dynamometer with a custom adapter on the syringe plunger was used:



- Measurements were done by trained staff under standardized conditions (syringe with closed-system-transfer-devices, class II biosafety cabinets).

- Reference force values and risk levels were defined according to UNE-EN1005-3:2002+A1. The maximum reduced isometric force (RBRF) for withdrawal and insertion was 1.83kg with tasks over 0.92kg considered ergonomic risks.

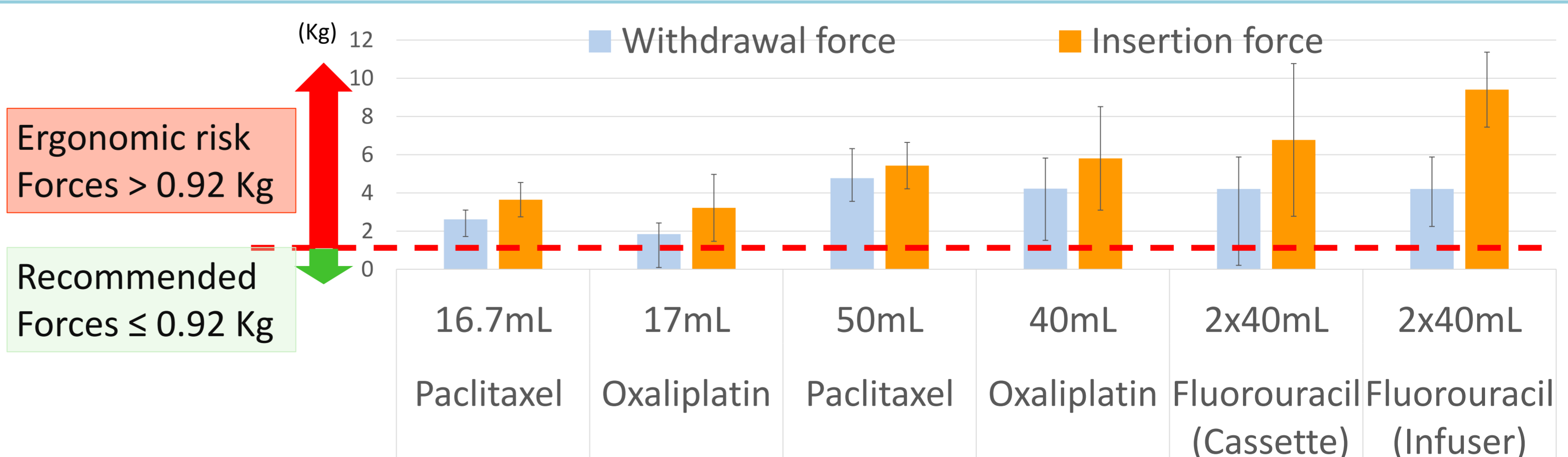
## Results

Nine technicians participated in the study; three per hospital (67% women, mean age 40±13years). Each technician performed three measurements (total of 27 measurements):

Drug	Doses (mg)	Volume (mL)	Syringe size(mL)	Final container	Withdrawal force (Kg) (SD)	Insertion force (Kg) (SD)
Oxaliplatin 100mg/20mL (aqueous drug)	200	40	50	250mL NS infusion bag	4.22 (1.60)	5.80 (2.71)
	85	17	20		1.81 (0.58)	3.22 (1.75)
Paclitaxel 300mg/50mL (viscous drug)	300	50	50	250mL NS infusion bag	4.77 (1.55)	5.43 (1.21)
	100	16.7	20		2.62 (0.48)	3.64 (0.90)
5-Fluorouracil 5000mg/100mL (large volume aqueous drug)	4000	80	50	Infuser	4.20 (1.68)	9.40 (1.96)
				Cassette	4.20 (1.68)	6.77 (4.00)

Oxaliplatin EFG Sun 100mg/20mL vial, Paclitaxel EFG Kabi 300mg/50mL vial, Fluorouracil EFG Accord 5000mg/ 100mL. BD Plastipak 20mL and 50mL Syringes. Grifols Fleboflex Luer Normal Saline infusion bag 250mL. Baxter Folfuser SV 2.5 infuser. CADD™ Medication Cassette Reservoir 100mL.

- **All manual preparations exceeded the recommended force limit**, with no significant differences between aqueous (oxaliplatin) and viscous (paclitaxel) drugs.
- Force differences were mostly related to **syringe volume** and **final container**, with the highest forces recorded during infuser insertion.
- For NS, WFI, and D5W, only syringes >10mL exceeded risk thresholds.



## Conclusion and Relevance

Manual compounding frequently exceeds ergonomic limits, especially with large volumes (>20mL) and infuser transfers. These data support prioritizing such tasks for robotic compounding (if available) to reduce musculoskeletal risk.

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