Technical Note:
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Ergonomics and usability study of Thermo Scientific Finnpipette F1 and F2 pipettes

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Background information

Pipetting is repetitive work performed with the thumb, fingers and wrist (Björksten et al. 1994, David and Buckle 1997, Fredriksson 1995). Research has shown that repetitive working movements are connected with upper limb strain injuries, or pain symptoms in the forearm, wrist and hand. Pipetting has been identified as a source of exacerbated upper limb symptoms, especially if performed for over 300 hours per year (Björksten et al. 1994).
Compared to the general public, laboratory workers suffer more from shoulder, hand and wrist symptoms (Björksten et al. 1994). In addition, research has proved that pipetting strains the muscles and joints of the shoulders, forearm, wrist and fingers, in particular (Lintula and Nevala 2006, Lu et al. 2008).

Objective of the study

The objective of the study was to evaluate the ergonomics and usability of six manual, single-channel pipettes. This was done by measuring the load and strain symptoms exhibited by workers' muscles and joints, and evaluating the usability features of pipettes in a simulated work situation.

Materials and methods

The six test pipettes are listed in Table 1 and shown in Figure 1. The test was performed with pipette tips recommended by the manufacturer of each pipette model. The testees were 10 healthy laboratory workers between the ages of 24 and 58, with pipetting experience of between 1 and 35 years. The testees spent on average 9 hours per week on pipetting. A simulated work situation was set up and the ergonomics and usability of pipettes were compared during a three-minute pipetting task: adding a tip, dispensing liquid (100 µl) from a test tube into a microplate, and ejecting the tip (Fig.2). The electrical muscle activity (i.e. electromyography or EMG) and wrist angle were measured. The measured muscles were the *flexor pollicis longus* (long flexor muscle of thumb), *flexor pollicies brevis* (short flexor muscle of thumb; Fig.3), *trapezius pars descendes* (the descending part of the shoulder muscle) and *extensor digitorum* (finger extensor). Prior to the task measurements, the maximum muscle electrical activity (MVC) was determined. The relative muscle strain of the pipetting task was calculated a follows: relative muscle strain (%) = (muscle strain during pipetting/maximum muscle strain) x 100.

Figure 1. Tested manual single-channel pipettes

Table 1. Model and size of tested pipettes

Code	Brand of pipette	Weight (g)	Length[a] (cm)	Circumference[b] (cm)
A	Gilson Pipetman Neo	111.3	24.3	10.0
B	Eppendorf Research plus	76.3	23.3	9.0
C	Thermo Scientific Finnpipette F1	67.9	22.2	9.3
D	Biohit mLine	75.7	22.5	9.4
E	Thermo Scientific Finnpipette F2	67.6	22.2	9.0
F	Rainin Pipet-Lite[c]	106.8	23.9	9.5

a The length of the pipette was measured from the top of the dispensing button to the end of the tip cone, when the largest volume was adjusted.
b The circumference of the pipette was measured at the thickest point of the handle.
c This model was selected based on its comparable tip ejection.

Figure 2. Pipetting task using a single-channel pipette

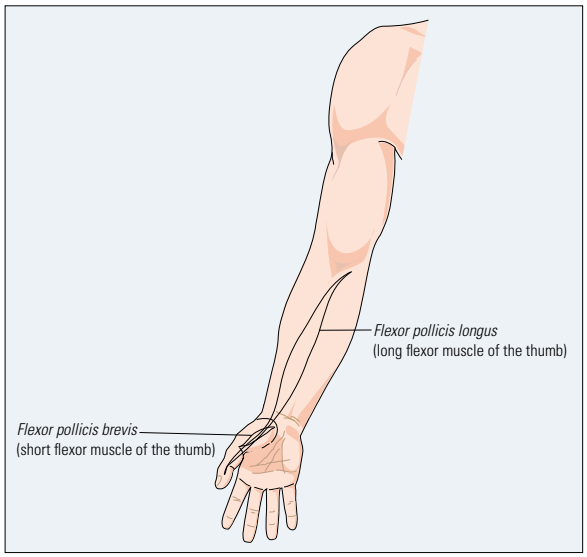

Figure 3. Simplified drawing of the location of the long and short flexor of the thumb.

In addition to the muscle strain and wrist angle measurements, the testees filled out a questionnaire on strain that they had experienced and on the pipettes' usability features. At the end of the test, the testees selected the three best pipettes and placed them in order of superiority by giving 5 points to the best pipette, 3 points to second best, and 1 point to the third best.

Results and discussion

Muscle strain measurements

Electrical muscle activity when working with different pipettes is shown in Figure 4. The relative strain on the finger extensors and on the short thumb flexor was smallest when working with the Thermo Scientific Finnpipette F1 and greatest when working with the Pipetman Neo.

Working with the Pipetman Neo strained the long thumb flexor significantly more than when using the Research plus, Finnpipette F1 or the Pipet-Lite. There was no statistically significant difference between the pipettes regarding the strain on the shoulder (results not shown).

Based on the results, the muscle strain was localized on the thumb long flexor area, as was pointed out in earlier studies (Lintula and Nevala, 2006). To reduce thumb strain and ease pipetting work, light pipetting and tip ejection forces are important features.

Laboratory work includes many other tasks that also stress the thumb, such as opening and shutting tubes. The strain on finger extensors varied significantly between the pipettes. Compared to all other pipettes, the stress was smallest when working with the Finnpipette F1. In addition to finger movements, the finger extensor participates in extending the wrist or maintaining the wrist position during pipetting.

The shape and firmness of the finger rest were connected to the strain on the finger extensors; a weaker finger rest resulted in greater muscle power being used in the area of the forearm extensor muscle group. The features of the Finnpipette F1 finger rest were considered the best and resulted in the least muscle strain, while the finger rest features of the Pipetman Neo were evaluated as being the weakest and the related muscle strain the greatest.

The muscle strain on all measured muscles was the greatest when working with the Pipetman Neo compared to the other pipettes. In addition, the Pipetman Neo differed most in its features from the other pipettes. It weighs approximately 1.5 times more than the lightest pipettes and is also the longest pipette, at 24.3 cm.

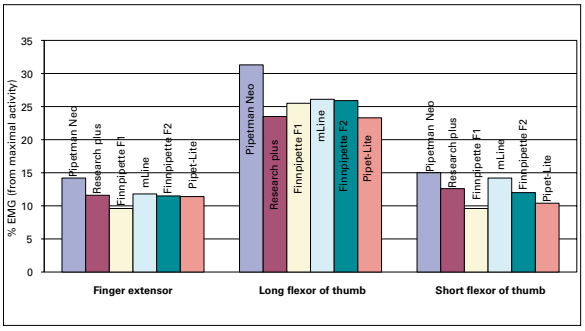

Figure 4. Average of electric muscle activity in different muscle groups during a three- minute pipetting task (n=10)

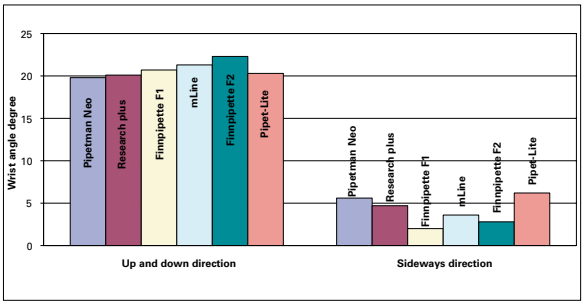

Figure 5. Average wrist angles during a three-minute pipetting task (n=10)

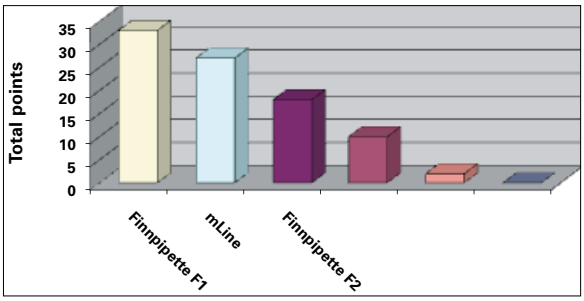

Figure 6. Pipettes' order of superiority set by the testees (n=10)

Wrist angle measurements

The average wrist angle in the up and down movement was between 20 and 22 degrees and in the sideways movement between 2 and 6 degrees (Fig. 5). The wrist angle in the up and down movement was smallest when using the Pipetman Neo and largest when working with the Finnpipette F2. The sideways bending angles were smallest when using the Finnpipette F1 and Finnpipette F2 and largest with the Pipetman Neo and Pipet-Lite.

The Pipetman Neo having the smallest wrist angle in the up and down movement could be linked to the lack of a proper finger rest, which makes the user press the pipette tighter into the palm of the hand and gives more control in achieving a better wrist position. This, however, increases the muscle strain in the forearm area.

The weight and length of the pipette may explain the significant differences in the sideways bending angle between the pipettes, because the Finnpipette F1 and Finnpipette F2 were the shortest and lightest of those studied. In addition, the first impressions of the testees indicated that the Finnpipette F1 was considered light and well-fitting in the hand, whereas the Pipet-Lite was considered heavy, clumsy and fitted poorly in the hand. The Pipet-Lite weighs 107 g, which makes it approximately 1.5 times heavier than the Finnpipette F1 and Finnpipette F2. Also, the shape of the finger rest and adequate support are characteristics that affect muscle strain and the pipetting posture.

The Finnpipette F1 has a new, unique adjustable finger rest. The testees' comments (see below) on their first impression indicate that the rotating finger support on the Finnpipette F1 enables a better fit in the hand, which can be assumed to improve work movements and posture, and ease working.

Comments on the Finnpipette F1 adjustable finger rest

- The excellent finger rest sits well in the hand.
- When pipetting, the adjustable finger rest feels good because the pipette fits better into your hand.
- The adjustable finger rest is a plus.
- The ability to move the finger rest is an excellent feature.
- The adjustable finger rest is good. Both right- and left-handed users can use it.

Pipetting strain and usability

A feeling of strain on the wrist, fingers and thumb was greatest when working with the Pipetman Neo. In addition, the feeling of strain in the neck and shoulder area, the upper arm and forearm was the greatest when working with the Pipetman Neo and the least with the mLine.

Regarding the variables depicting pipette usability, the Finnpipette F1 received the best evaluation for 16 out of 19 characteristics. In statistical terms, the usability features of the pipettes Finnpipette F1, mLine and Finnpipette F2 were notably better than with the Research plus, Pipet-Lite and the Pipetman Neo.

The pipette users' subjective evaluation of the pipettes' usability correlated well with the objective strain measurements. The pipettes considered good in terms of usability caused fewer strain symptoms than those considered poor in the same respect. The Pipetman Neo, which deviated most in its pipette features from the other pipettes studied, was considered to cause the most strain on the forearm and hand area during work.

Order of superiority

The Finnpipette F1 was ranked the best by five (50%) testees, mLine by four (40%) testees and the Finnpipette F2 by one (10%) testee. In terms of order of superiority, the Finnpipette F1 received the highest score, mLine the second highest and the Finnpipette F2 the third highest (Fig. 6).

Conclusions

On the basis of the research, the following conclusions can be made:

1. Pipetting with the Finnpipette F1 caused the least muscle strain (2 muscles) and pipetting with the Pipetman Neo the highest (4 muscles). The sideways bend in the wrist was smallest with the Finnpipette F1.

2. Of the studied pipettes, the Finnpipette F1's usability was ranked the best, mLine's second best and the Finnpipette F2's third best. The Pipetman Neo was assessed as being the worst pipette in terms of its usability features.

3. The Finnpipette F1's new feature, the adjustable finger rest, was generally considered a good innovation. In particular, its benefits during pipetting were thought to receive a particular emphasis in ambidextrous pipetting. This feature should be emphasized in order to even out the work load and ease pipetting.

References

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