

Comparing the Level of Dexterity offered by Latex and Nitrile SafeSkin Gloves

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An increase in the occurrence of latex allergy has been concurrent with the increasing use of latex gloves by laboratory and healthcare workers. In recent years nitrile gloves have been used to replace latex gloves to prevent latex allergy. Nitrile gloves offer a comparable level of protection against chemical and biological agents and are more puncture resistant. However, if manual dexterity is compromised by nitrile gloves to a greater degree than latex then this may increase the risk of sharps injuries. The Purdue pegboard test, which measures both gross and fine finger dexterity, was used to test the dexterity levels of two glove types used at HPA CEPR; Kimberly-Clark SafeSkin nitrile and latex laboratory gloves. There was a statistically significant 8.6% increase in fine finger dexterity provided by latex compared with nitrile SafeSkin laboratory gloves but no difference in gross dexterity between the glove types. There was no significant relationship between glove dexterity and age or gender. The selection of glove size was influenced by the digit length of participants. Moreover, those with longer, thinner fingers appeared to have an advantage when using nitrile SafeSkin gloves. The level of dexterity provided by latex and nitrile SafeSkin gloves for tasks on a gross dexterity level are comparable and health workers will benefit from the non-allergenic properties of nitrile. For tasks requiring fine finger dexterity nitrile SafeSkin gloves may impede dexterity. Despite this, the degree of restriction appears to have a negligible impact on safety in this study when compared with the risk of latex sensitization and subsequent allergy. In addition to glove material, working practices must also take into account glove size, fit, grip and thickness, as these factors can all influence dexterity.

Keywords: biosafety; dexterity; latex gloves; manual dexterity; nitrile gloves

INTRODUCTION

The dramatic increase in the use of latex gloves began in the 1980s following a greater awareness of HIV/AIDS. The incidence of natural rubber latex (NRL) allergy became more common as a result (Turjanmaa, 1995; Edlich *et al.*, 2003; Ranta and Ownby, 2004) and alternative glove materials were sought. A range of glove materials were tested for barrier effectiveness against bloodborne pathogens (Rego and Roley, 1999), simulated clinical use (Korniewicz *et al.*, 2002), puncture resistance (Fisher *et al.*, 1999; Patel *et al.*, 2004) and durability (Kerr *et al.*, 2004), and in all these tests vinyl and copolymer gloves gave a worse performance than latex gloves. However, nitrile gloves gave a performance comparable with latex. Many hospitals and laboratories are now replacing

latex with nitrile gloves, and several studies have documented a reduction in the incidence of latex allergy when implementing this policy (Allmers *et al.*, 2002; Hunt *et al.*, 2002). It is envisaged that more institutions will switch from using latex to nitrile gloves in the future.

Nitrile gloves have different physical properties to latex (Fisher *et al.*, 1999; Jackson *et al.*, 1999; Patel *et al.*, 2004), which could affect the dexterity of the user. Recent research has shown that dexterity can be adversely affected by the use of latex (Neiburger, 1992) and chemical protective gloves (Bensel, 1993), the type of containment equipment used, and also by using the wrong glove size. There has been suggestion that nitrile gloves may produce finger and hand fatigue over time due to the inflexibility of the glove material (Morris, 1994; Korniewicz *et al.*, 2004).

A reduction in dexterity caused by wearing certain types of laboratory gloves could increase the risk of

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injury from sharps or chemical spills for health and laboratory workers. Therefore, the aim of this study is to use the Purdue pegboard test to quantify the dexterity levels provided by the type of latex and nitrile laboratory gloves used at the Health Protection Agency, Centre for Emergency Preparedness and Response (HPA CEPR). The influence of age, gender and digit size will also be investigated. Although this study relates to workers at HPA CEPR, it is anticipated that laboratory and healthcare workers on a wider scale will find the results of value.

METHODS AND MATERIALS

Two types of gloves used for a range of laboratory work at HPA CEPR were tested, shown in Fig. 1.

- Latex SafeSkin gloves (Kimberly-Clark SafeSkin Satin Plus powder-free latex exam gloves. Ref. SP2330E)
- Nitrile SafeSkin gloves (Kimberly-Clark SafeSkin Purple Nitrile-xtra powder-free exam gloves. Ref. 50602M)

Purdue pegboard dexterity test

Previous work has shown that dexterity consists of a variety of factors (Fleischman and Hempel, 1954) and several tests exist, which measure these factors. For example, the O'Connor tweezer test measures the ability to manipulate small hand tools, whereas the steadiness test measures the ability to hold a probe still in one position for an extended period. The Purdue pegboard test (Lafayette Instrument model 32020) shown in Fig. 2, was selected for use in this study because it measures both large and small movements of the arms, hands and fingers, reflecting manipulations carried out in laboratory work. The pegboard measures both 'gross dexterity', which is the gross movement of hands, fingers and arms, and 'fine finger dexterity', which is defined as the ability to coordinate finger movements in performing fine manipulations (Tiffin, 1948; Fleischman and Hempel, 1954) using a series of four tests.

Test administration

This was based on the method described and well validated previously (Tiffin, 1948). Dexterity in the Purdue test is measured as the number of pegs correctly placed in the holes of the pegboard. Gross dexterity is measured using the combination test, which is the sum of the number of pegs placed first with the dominant, then the non-dominant hand and then with both hands in the holes in 30 s for each part of the test. The assembly test measures fine finger dexterity and requires the construction of 'assemblies' of washers, pegs and collars using both

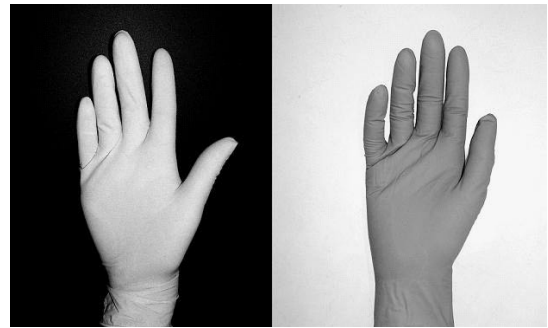


Fig. 1. Left: latex SafeSkin glove, right: nitrile SafeSkin (purple) glove.



Fig. 2. The Purdue pegboard test.

hands working simultaneously in 60 s. To standardize the test, each subject practiced before the test began.

The pegboard dexterity tests were completed by 24 participants using the two glove types. To counter any order effects, one group of participants was tested wearing the latex gloves first, then the nitrile. The other group were tested using nitrile gloves first, then latex. Each group consisted of 12 randomly assigned participants.

Glove selection

Before testing, participants were asked the following questions and their answers were recorded.

- Do you usually use latex or nitrile gloves in your job?
- Given the choice, which gloves do you prefer, latex or nitrile?

Participants were asked to select the glove size that they would normally use.

Hand dimensions

Measurements for the dominant hand of each subject (shown in Fig. 3) were taken using callipers and recorded prior to the dexterity testing.

- Width of thumb, index and the middle finger at a halfway point on the distal phalange.
- Length of thumb, index and middle finger.

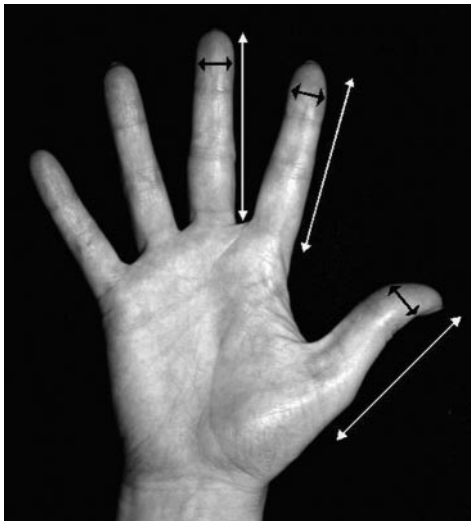


Fig. 3. Arrows denote digit measurements taken from participants.

Statistical analysis

The data were analysed using the statistical software package Minitab Release 13.32 (Minitab Ltd), using the general linear model (GLM), and Pearson product moment correlation coefficient programs. Where appropriate, one-way or two-way repeated measures ANOVAs were performed. Data were transformed using the Box-Cox transformation when necessary, to meet parametric assumptions. The lambda (λ) value used is given for each transformation in the results. *t*-Tests were used to compare the means of data and Pearson's correlation determined any relationships between the anthropometric measures, questionnaire data and dexterity test scores. The alpha level was set at 0.05 for statistical significance.

RESULTS

Gross dexterity

The data were transformed to fit parametric assumptions ($\lambda = -1$) and a paired *t*-test identified a marginal trend of higher gross dexterity when using latex gloves compared with nitrile. However, the difference between the two types was very small and did not reach the 5% level of significance required ($t = 1.79$; $P = 0.087$).

Gross dexterity was measured using the Purdue pegboard by adding the scores of the dominant hand, non-dominant hand and both hands. Further analysis assessed any difference between the individual dexterity scores of the dominant hand, non-dominant hand and both hands as affected by glove type. These data were transformed ($\lambda = -0.5$) and a two-way repeated measures ANOVA found a statistical difference in dexterity between the hand/s

used ($F = 16.6$; $P < 0.001$) but no difference between the two glove types. There was also no statistical interaction between the hand used and glove type.

The gross dexterity level provided by both glove types is illustrated in Fig. 4.

Fine finger dexterity

The data for this analysis were transformed ($\lambda = -0.5$) and latex gloves gave significantly higher fine finger dexterity scores than nitrile ($t = 3.14$; $P = 0.005$). Comparing the fine finger dexterity score means, nitrile gloves reduced fine finger dexterity by 8.6% compared with latex gloves.

The fine finger dexterity level provided by both glove types is illustrated in Fig. 5.

Thumb and finger dimensions

The ranges and means of the dimensions of the participants' digits are shown in Table 1. From the measurements taken, the digit that varied the most in width was the thumb whereas the index finger varied most in length.

Weak but statistically significant correlations were found between the dexterity scores from the two glove types and the digit dimensions taken.

- Width of index finger has a weak negative correlation with dominant hand nitrile scores (correlation = -0.492 ; $P = 0.015$), both hands nitrile scores (correlation = -0.467 ; $P = 0.021$) and overall dexterity nitrile scores (correlation = -0.477 ; $P = 0.018$).

Additional correlations were found that did not reach the significance level of 5% but would be considered a trend ($>10\%$), which followed a pattern of thinner, longer thumbs and index fingers being associated with improved dexterity.

Figures 6 and 7 illustrate that participant's choice of glove size is a reflection of their hand size.

The SafeSkin glove size selected by participants was influenced by their digit length. There was a significant difference between the SafeSkin glove sizes for length of thumb ($F = 5.28$; $P = 0.014$) with the difference between the small and large SafeSkin glove size being significant with a 95% confidence interval (1.983–15.617). The significant difference between the SafeSkin glove sizes based on index finger length ($F = 5.25$; $P = 0.014$) was also due to the significant difference in index finger length between the large and small SafeSkin gloves (2.645–21.088). Finally the middle finger length also gave a significant difference in SafeSkin glove size ($F = 5.92$; $P = 0.009$), which was due to the difference between the large and small SafeSkin gloves (2.854–18.879). However, there was no significant difference in thumb, index or middle finger width between the SafeSkin glove sizes.

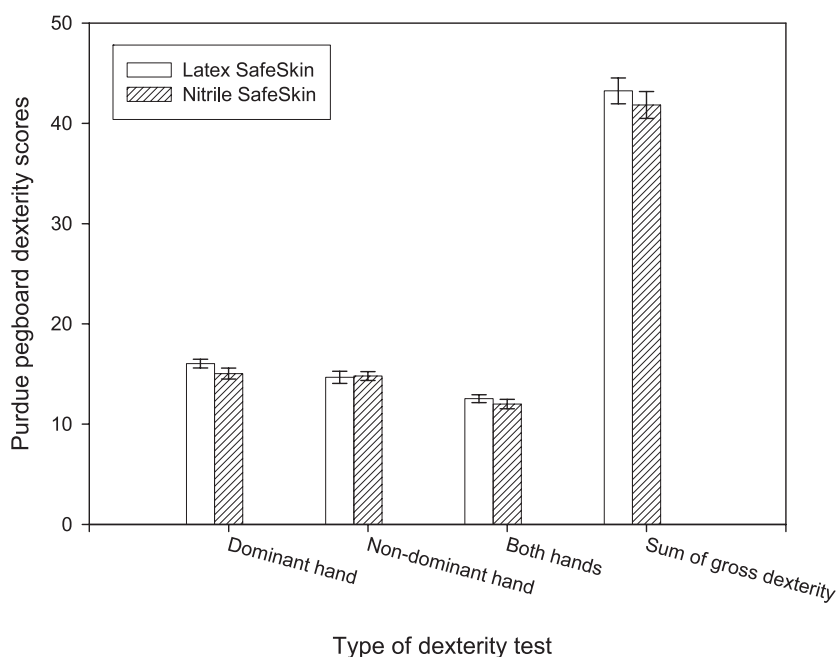


Fig. 4. A comparison of the two types of gloves tested, from the levels of gross dexterity each type provided.

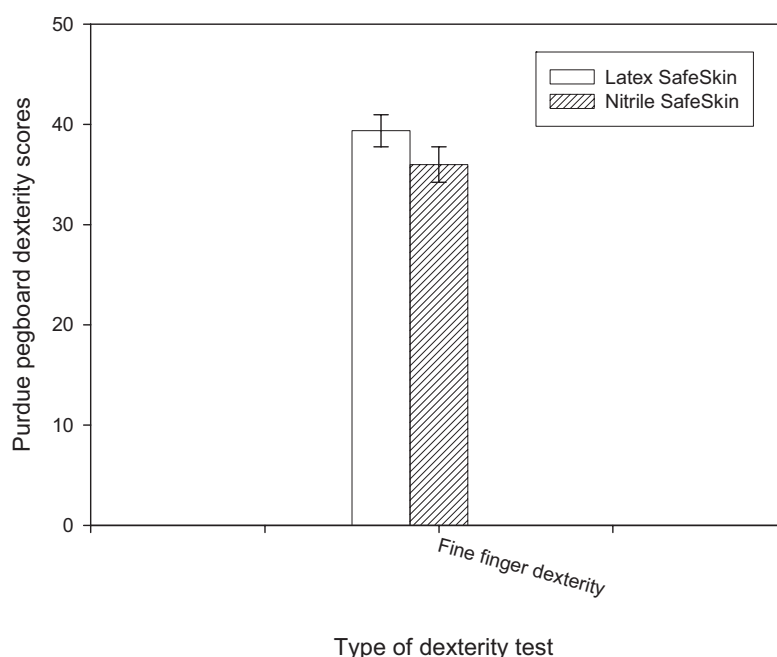


Fig. 5. A comparison of the two types of gloves tested, from the levels of fine finger dexterity each type provided.

There was no statistically significant difference in the digit length or width of the participants between the latex and nitrile SafeSkin glove sizes chosen. Despite this finding, 4 out of 24 participants did select a nitrile SafeSkin glove one size bigger than their chosen latex glove size, whereas none selected a nitrile SafeSkin glove that was smaller than their chosen size of latex SafeSkin glove.

Glove preferences

Participants were questioned about the SafeSkin gloves they use and prefer. Of the participants tested, 83% usually or always use latex SafeSkin gloves and the remainder use nitrile SafeSkin gloves. Of the participants tested, 67% prefer using latex, 21% prefer nitrile SafeSkin gloves and 12% expressed no preference. Some participants gave reasons for

Table 1. The means and ranges of the digit dimensions measured of the 24 participants

Digit and dimension	Mean	Range (min–max)
Thumb width	19.8	15–25
Index finger width	15.9	12–19
Middle finger width	16.2	13–21
Thumb length	64.5	59–72
Index finger length	71.1	62–82
Middle finger length	78.4	70–89

their choice of glove, which included being concerned about latex allergy or preferring the fit and feel of their chosen glove type.

Age and gender

The ages of the participants tested ranged from 20 to 48, with a mean age of 31.2. There were 54% male and 46% female participants within the population. There was no significant correlation between age or

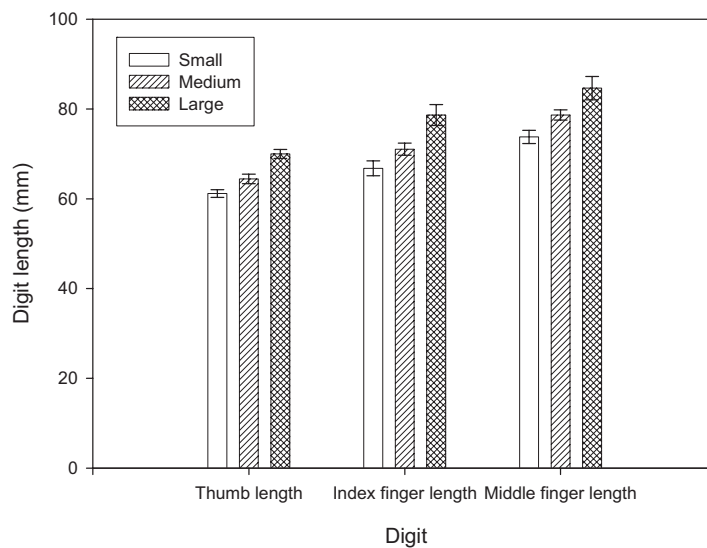


Fig. 6. Mean digit lengths grouped by participant's latex glove size preference.

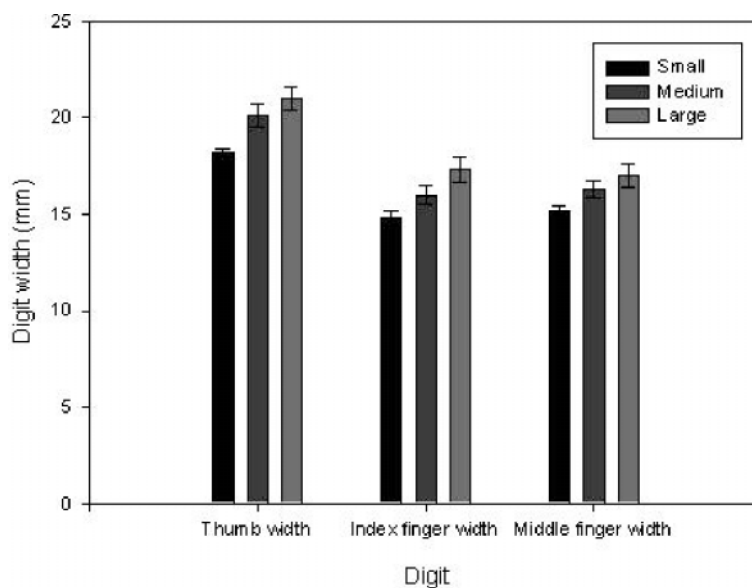


Fig. 7. Mean digit widths grouped by participant's latex glove size preference.

gender and dexterity test performance with any glove type.

DISCUSSION

SafeSkin glove types

Many laboratories are switching from latex gloves to nitrile in an attempt to reduce latex allergy prevalence for the workers. Laboratory gloves with a high level of dexterity are an essential requirement at HPA CEPR to reduce the risk of accidents and injury, and any switch from latex to nitrile must not result in an appreciable loss of dexterity. Nitrile SafeSkin gloves were found to provide 8.6% less fine finger dexterity compared with latex, although there was no difference in gross dexterity. Thus the nitrile SafeSkin gloves only impeded smaller movements of the fingers not the larger movements of the hands and arms. The latex and nitrile used in the manufacture of SafeSkin gloves have a range of different properties, thus there may be a combination of reasons for this reduction in dexterity.

SafeSkin gloves and hand size

Comments from participants during testing suggested that the nitrile SafeSkin gloves were narrow across the hand width and if the next size up was taken, the glove fingers were too long. Thus, although the nitrile SafeSkin gloves may favour those participants who had longer, thinner fingers, they would impede those with shorter, wider digits. Longer fingers would be expected to improve dexterity when wearing larger gloves, to reduce any overhang at the end of the glove fingers. Conversely wider fingers reduce dexterity (Peters *et al.*, 1990) by impeding the manipulation of the pegs. The results of this study reflect a trend of improved dexterity in nitrile gloves with longer, thinner fingers. Although the correlations found between digit size and dexterity for nitrile gloves are significant, they are weak. However a causal relationship can exist even though only a weak correlation is apparent.

Gloves that are too large have excess or slack at the fingertips, which can get trapped and may also obstruct vision. Gloves that are too small can cause discomfort and restriction, particularly when worn over a long period of time. The measurements collected from the current study showed that people's finger sizes varied not only in overall size but also in the ratio of width to length, even between the fingers of the same individual. This creates a problem for glove manufacturers, who have to establish an 'average sized' set of dimensions to produce gloves that fit the majority of people.

Participants chose SafeSkin latex glove size to match their digit size, with people with longer digits

selecting larger gloves. Of the participants, 17% selected a nitrile glove one size bigger than their chosen latex glove size. None of them selected a nitrile SafeSkin glove that was smaller than their chosen size of latex glove. This implied that the nitrile gloves are perceived by users to be a tighter fit, even though no obvious statistical relationship between digit size and latex or nitrile glove type can be found. However, hand width and other hand measurements were not taken. The optimum glove fit may depend more in the fit for the hand than the digits, even though the digits are more directly involved in manual dexterity. Several participants commented that the nitrile gloves were not wide enough across the hand, even though the fingers for their selected glove size fitted well. Moving up to the next sized nitrile laboratory glove for some people gave a glove that fitted across the hand width, but became too large in the fingers. This may again be due to the extra stretch that latex has, providing a more flexible fit to a range of hand sizes (Fisher *et al.*, 1999).

Glove thickness

In addition to the elasticity of the two glove materials, the latex SafeSkin gloves were also slightly thicker than nitrile SafeSkin gloves. Nitrile is a stronger material than latex so it can be much thinner than latex and still be as puncture resistant (Fisher *et al.*, 1999). The thickness of each SafeSkin glove are listed in Table 2.

Thicker gloves reduce fingertip sensitivity, which has a detrimental effect on fine finger dexterity. Thus latex SafeSkin gloves provide greater dexterity, despite being a thicker material. This suggests that the other properties of the latex SafeSkin gloves compared with nitrile, such as the elasticity providing better fit, and the less smooth, almost tacky surface are the key to the increased fine finger dexterity.

SafeSkin glove type preferences

From the questionnaire, at HPA CEPR, most workers use latex SafeSkin gloves although some departments and individuals concerned about latex allergy have switched to nitrile SafeSkin gloves. Consequently, the majority of participants who preferred latex gloves when questioned may do so simply owing to familiarity. A fear of latex allergy was the reason given by some participants for preferring nitrile, rather than comfort of fit or improved dexterity. Worker perception is not necessarily the best

Table 2. Thickness of the two types of gloves tested, taken from the following website: <http://www.safeskin.com>

Gloves	Glove thickness (mm)
Latex SafeSkin	0.17 (fingertip), 0.14 (palm)
Nitrile SafeSkin	0.15 (fingertip), 0.12 (palm)

judge of the dexterity levels offered by a glove type. Surgeons have been encouraged to double glove as this makes detecting punctures in the gloves easier and improves protection (Laine and Aarnio, 2001). However it appeared that there was reluctance among surgeons to double glove, under the assumption that this would reduce manual dexterity (St Germaine *et al.*, 2003). Glove selection should be based on a logical comparison of the types available, based on the level of dexterity provided and chemical permeability. Assumptions made by workers about glove types are not necessarily accurate. However, in this study, worker preference for latex SafeSkin gloves was supported by the increased fine finger dexterity provided by these gloves.

Age and gender

There was no significant difference between the genders related to glove type and dexterity scores. Although it may be expected that dexterity decreases with age, in this instance there was no direct correlation. However, the oldest person tested was 48 and dexterity may not sharply decline owing to age until much later (Haward and Griffin, 2002).

Glove selection

Upon wearing the two types of SafeSkin glove in turn, latex appeared to offer a better fit that moulded to the hand. The nitrile material seemed to have less 'give' to it (Morris, 1994; Fisher *et al.*, 1999). Despite this, a comparison of the latex and nitrile gloves found no significant difference in the level of gross dexterity and only a limited reduction of fine finger dexterity.

This study relied upon gloves being worn for relatively short periods of time, for only 5–10 min. Under real working conditions a longer 'wear' time may increase the difference in dexterity between latex and nitrile due to the possible reduced/constricted fit of the nitrile SafeSkin gloves. Moreover, only one type of glove from one manufacturer was tested. The results from the SafeSkin gloves tested might not reflect the difference between latex and nitrile gloves from other manufacturers. However, Kimberly-Clark SafeSkin gloves are a brand that is widely used in many laboratories and it is hoped this study provides valuable information about this glove type. Additionally, any slight reduction in dexterity by nitrile gloves can be mitigated, as is routinely done in class III cabinet work where dexterity is severely restricted, by increasing the time given to complete tasks.

Thus a switch from latex SafeSkin to nitrile SafeSkin gloves in response to the reported increase in NRL allergies should not seriously compromise worker safety in terms of dexterity. A reduction in latex sensitization among laboratory workers would outweigh any impact found by this study on dexterity.

CONCLUSIONS

Nitrile SafeSkin gloves offered an alternative to latex that will not promote latex allergy at the HPA CEPR, but it was not known whether the levels of dexterity were comparable. Both glove types were tested using the Purdue pegboard to measure dexterity. Despite being a thicker material, SafeSkin latex gloves provided an 8.6% higher level of fine finger dexterity compared with SafeSkin nitrile gloves. There was no significant difference between the gross dexterity provided by latex and nitrile SafeSkin gloves and no relationship between age and gender for the dexterity provided by any of the gloves tested.

Participants with shorter fingers appeared to have reduced dexterity with the nitrile SafeSkin gloves, but there was no reduction in dexterity with the latex gloves. This could be an artefact of the lack of elasticity in nitrile SafeSkin gloves compared with latex. Nitrile SafeSkin gloves also were perceived by some participants to be a tighter fit than latex. Perhaps the manufacturers of SafeSkin need to reassess nitrile glove size to provide an optimum fit.

The majority of participants both preferred and use latex SafeSkin gloves. This could be a consequence of familiarity as many participants had not used nitrile gloves before. However, although in this study the perception of glove users that nitrile gloves seriously reduces dexterity is unfounded, tasks requiring fine finger dexterity should be given extra time if necessary.

Nitrile SafeSkin gloves should be considered a non-allergenic alternative to latex SafeSkin gloves that does not seriously compromise dexterity. This information should not only be valuable to the HPA CEPR but also will benefit laboratory and healthcare workers.

Further work

Only two types of gloves from one manufacturer were assessed in this study. Many types of gloves are on the market, and the majority advertised the high levels of dexterity provided. Despite this, no data were provided to back these claims. Recommendations for further work include the assessment of dexterity levels provided by other gloves from a range of manufacturers. A dexterity test based directly on common laboratory techniques may provide further data on the suitability of different types of gloves for specific tasks. Additionally, latex and nitrile gloves should be compared and tested for longer periods of time to mimic and assess the effects of hand and digit fatigue that can occur during laboratory work.

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