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# Using face masks with spectacles versus contact lenses

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ABSTRACT

*Purpose:* To test the hypothesis that various subjective ocular and task-related parameters associated with wearing a face mask would be better in neophyte contact lens (CL) wear compared to habitual spectacle (Sp) wear.

*Methods:* Thirty participants were randomised to continue in Sp (n = 15) or wear somofilcon A daily disposable CL (n = 15) ('group'). A surgical face mask (Type II R) was worn for at least one hour per day on four or more days per week. After two weeks, participants completed the Quality of Life Impact of Refractive Correction Questionnaire (QIRC), a two-part face mask usability questionnaire and graded ocular-related symptoms using 0–100 visual analogue scales.

*Results:* There was no difference between groups for overall QIRC score but some individual question scores reflected better quality of life in the CL: 'outdoor activities', 'keep fit' and 'able to do things' (all $p < 0.05$). Differences in favour of the CL were seen for the following in the face mask usability questionnaire: 'breathing', 'heat', 'comfort on ears', 'overall comfort', 'walking', 'driving', 'reading', 'computer use', 'exercising' and 'socialising' (all $p < 0.05$). Significant differences were also seen for the 0–100 VAS symptoms probing vision quality in favour of the CL: glare, distance and near vision, fogging, restricted field of view and peripheral blur.

*Conclusion:* This work supports anecdotal reports that CL are a better vision correction option than Sp when used in conjunction with a face mask. Participants reported a range of benefits to the CL/face mask combination for vision-related symptoms, breathing and heat-related symptoms and a number of day-to-day activities including walking, driving and exercising. All of the benefits relating to the CL are likely to result in improved adherence to face mask use. Overall, the findings of this work suggest that where possible, CL should be the preferred vision correction option for people using face masks.

## 1. Introduction

The COVID-19 pandemic has resulted in millions of deaths worldwide and widespread severe social disruption [1–3]. Although the routes of transmission of the causative virus (severe acute respiratory syndrome coronavirus 2, SARS-CoV-2) were initially debated [4–7], the current scientific consensus is that the primary route is via airborne droplets and aerosols produced in the upper respiratory tract of those infected [8–10].

In the early stages of the pandemic, the World Health Organisation advised against the use of face masks by the general population because there was insufficient evidence to indicate that they were effective at controlling the spread of the virus. Additionally, there were concerns regarding the potential for self-contamination during mask handling and that use of medical face masks by the public might deplete supplies for healthcare workers [11]. However, studies have now shown that the use of face masks by the general population has a positive impact in reducing viral transmission [12–15].

Face masks are thought to be effective because they reduce viral transmission by both source control (preventing a potentially infectious individual contaminating the surrounding environment) [16,17], and act as personal protective equipment (PPE), where the face mask reduces the risk of the wearer becoming infected as a result of filtration of inhaled air. Although the properties and fit of a mask influence its filtration efficiency [18,19], all face masks appear to show some ability to protect the wearer from aerosol exposure and limit the amount of airborne droplets produced [20]. A further benefit may relate to a reduced tendency for direct contact between the hands and the nose/

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mouth [21]. These findings, together with the fact that individuals are typically most infectious prior to the onset of symptoms [22–24], or may be entirely asymptomatic [25], further support the use of face masks by the general public which has led to many governments making face masks mandatory in public spaces [26]. In addition to widespread testing, contact tracing, hand washing, quarantining of potential infectious individuals and physical distancing, face masks are a valuable tool in reducing community transmission of SARS-CoV-2 [12]. There is speculation that the wearing of face masks may continue globally (particularly in Western countries) in certain settings in a similar way to what has occurred in many East Asian countries prior to the COVID-19 pandemic [27,28].

Face masks have been associated with a range of deleterious consequences including dry eye [29,30], spectacle lens fogging [31], feeling hot [32], itchiness [33], acne [34,35], skin allergies [36], feelings of 'tightness' [37], breathing difficulties [38,39], disturbed peripheral vision [40], risk of falls [41] and headaches [42,43]. In the healthcare setting, fogging of spectacle lenses whilst wearing a face mask has long been acknowledged [44], but with the recent widespread use of face masks this has become a much more frequently reported complaint [31].

Fogging can occur during normal spectacle wear; for example, when a wearer passes from a cold to a warm humid environment, and condensation forms on the lens surfaces. When a face mask is worn this problem is exacerbated as the fit of the mask is generally poorest in the highly curved region around the bridge of the nose, which results in a rapid upward flow of warm, humid air in this region as the wearer exhales. Condensation can then form on the relatively cool and hydrophobic lens surfaces and tiny light-scattering microdroplets can disturb the optical properties of the lenses, resulting in degraded vision. Any difficulty in wearing a face mask, particularly any visual impairment, is likely to deter the user from wearing the mask correctly, or perhaps at all, leading to lower levels of protection. Spectacle fogging could also have safety implications since it generally does not clear rapidly and it is often dealt with by the wearer lifting their spectacles out of their line of sight, resulting in a period of uncorrected vision.

In order to address this issue, a range of possible solutions have been proposed, including the application of tape [45] or clips [46] at the top of the mask, hydrophilic treatments to the lens surfaces [47], moving the spectacles further down the nose [48], consciously breathing downwards [48] or adjusting/changing the mask to improve the fit at the bridge of the nose [19,49]; however, none of these solutions truly solves the issue without introducing further negative or unwanted effects.

A more satisfactory solution to this problem could be to wear contact lenses since a contact lens is maintained at around body temperature [50] and due to the aqueous nature of the tear film, surface condensation cannot occur. Given the obvious apparent benefit of contact lens wear when a face mask is used, the purpose of this work was to test the hypothesis that various subjective ocular and task-related parameters associated with wearing a face mask would be better in a group of neophyte contact lens wearers compared to a group of habitual spectacle wearers.

## 2. Methods

### 2.1. Study products

Somafilcon A contact lenses (clariti® 1 day, CooperVision Inc.) were randomly fitted to 50% of the study cohort as described below. The lenses had a back optic zone radius of 8.6 mm and a total diameter of 14.1 mm. The lens was chosen as a representative example of a modern, commonly-prescribed silicone hydrogel daily disposable lens. Lenses were worn bilaterally on a daily wear, daily disposable basis.

The face mask used in this investigation was the Yeso-med® Type IIR disposable surgical mask (Wuxi Yushou Medical Appliances Co. Ltd, China and EU Authorised representative Shanghai International Holding Corp. GmbH, Germany) (Fig. 1) which are produced to European

**Fig. 1.** The Yeso-med® Type IIR surgical face mask.

standard EN14683. Surgical face masks specified in this standard are classified into Type I and Type II according to bacterial filtration efficiency and Type II masks are further divided according to whether or not the mask is splash resistant, indicated by 'R'. Type IIR masks must have a bacterial filtration efficiency of $\geq$ 98%, differential pressure (breathability) of $<$ 60 Pa/cm$^2$, splash resistance $\geq$ 16 kPa and microbial cleanliness $\leq$ 30 cfu/g [51]. The masks consisted of three layers comprising a pleated design with ear loops and a metal nose bridge enhanced the fit by allowing the mask to follow the contours of the nose and cheeks. Participants were supplied with 50 masks (one sealed box) and asked to wear them for the majority of the time that a face mask was needed and for at least one hour per day, for at least four days per week.

### 2.2. Study design

This was a prospective, randomised, two-arm parallel group investigation. Ethical approval was granted from the University Research Ethics Committee of The University of Manchester after completing appropriate risk assessments and adaptation of processes to minimise risk to participants and investigators during the COVID-19 pandemic. The study conformed to the tenets of the Declaration of Helsinki and all participants were provided with written, informed consent prior to enrolment.

In order to determine the sample size, power analysis was undertaken for the Quality of Life Impact of Refractive Correction Questionnaire (QIRC) using data from a previous investigation. A power of at least 80% was provided by 30 datasets (15 participants in each group) assuming a difference of 7 units (QIRC scale range 0 to 100) and a standard deviation of 6.4 units. This assumed a two-tailed unpaired analysis and an alpha of 0.05.

Participants attended two visits which took place two-weeks apart. All participants were required to be habitual wearers of single vision spectacles and never have worn contact lenses (with the exception of a trial fitting). The full list of inclusion and exclusion criteria are outlined in Table 1. At the initial visit, eligible participants were randomly (and equally) allocated to one of the two study groups: 1) remained in their habitual spectacles (spectacle group) or 2) fitted with the study daily disposable contact lens (contact lens group). At the initial visit various baseline investigations were carried out including subjective refraction, visual acuity (logMAR), and slit lamp biomicroscopy. The back vertex power of the habitual spectacles for each participant was measured to ensure they were within $\pm$ 0.50 DS of the measured refraction.

A QIRC questionnaire was completed; this instrument is designed to measure quality of life in people who require a refractive correction [52]. The 20 questions are scored using a 5-category response scale (1–5), with a sixth 'not applicable' option available. This was followed by a two-part 'face mask usability' questionnaire. The first part of the face mask useability questionnaire consisted of six questions (breathability, heat, tightness, ease of talking, comfort on ear lobes and overall comfort) and was used in the same way as Or et al [53] who investigated

**Table 1**
Inclusion and exclusion criteria.

| Inclusion criteria | Exclusion criteria |
|---|---|
| 18 to 40 years old | Ocular or systemic disease which would normally contraindicate contact lens wear |
| No previous contact lens wear, with the exception of a trial fitting | Requirement to use any topical medication (e.g. drops) during the study |
| Sphere between + 8.00 and −10.00DS in each eye (based on ocular refraction) | History of cataract or refractive surgery or corneal distortion |
| Cylinder of −0.75DC or less in each eye (based on ocular refraction) | Required significant ocular/face personal protective equipment beyond a personal face mask (e.g. specific occupational need) |
| Owns and habitually wears single vision spectacles | Habitual spectacles not within ± 0.50DS of refraction at baseline |
| Willing to wear the assigned vision correction at least 8 h a day, 5 days per week | History of anaphylaxis or severe allergic reaction |
| Able to wear the study face masks for the majority of time that a mask is required | Pregnant or breast-feeding |
| Willing to wear the study face masks for at least 1 h per day, at least 4 days per week | Participation in any other contact lens or care solution clinical study within 2 weeks of starting this study |
| Could achieve 0.2 logMAR distance high contrast visual acuity with the randomised vision correction | |

the usability of N95 respirator face masks when different fit tests had been undertaken prior to tasks performed by student nurses. These six questions were adapted by Or et al [53] from the work of Li and colleagues [32] who originally asked these questions in a comparison of N95 and surgical masks using 0–10 grading scales. As such, these questions are also relevant to the present investigation. Each question was scored using a 5-category response scale (1 = very unsatisfactory, 2 = unsatisfactory, 3 = average, 4 = satisfactory and 5 = very satisfactory). The second part of the questionnaire consisted of nine questions developed for this clinical investigation (Table 2). Finally, subjective scores using 0–100 visual analogue grading scales (VAS) were completed for the following nine ocular-related symptoms: distance vision, near vision, ocular dryness, ocular comfort, ocular redness, fogging, glare, restricted field of view and peripheral blur. All questionnaires were completed in the presence of the investigator.

Participants assigned to the contact lens group were fitted bilaterally with the study lenses and following at least five minutes of settling time, lens fit was assessed using −2 to + 2 grading scales for horizontal and vertical centration, corneal coverage and movement. If this was deemed unacceptable (any of the parameters were graded as '2'), the participant was exited from the study. High illumination logMAR visual acuity (high contrast) was recorded before and after over-refraction. An alternate lens back vertex power was selected if an over-refraction of ± 0.50DS or more was found. Participants were trained on contact lens application, removal and best daily lens care practice. Additionally, instruction was given on donning (putting on) and doffing (taking off) procedures for the face masks for all participants, including how best to mould the nose bridge.

All participants were asked to wear their assigned vision correction for a minimum of eight hours per day, five days per week over the two-week study period. No gradual adaptation period was used for the neophyte contact lens wearers since there has been shown to be no clinical benefit for this approach in daily disposable wearers [54]. They were advised to attend the two week follow-up visit wearing the assigned vision correction, and to have worn the correction for at least two hours before the visit. A short message service (SMS) text message was sent to the mobile phone of each participant every other evening to capture a score for 'overall performance' of their vision correction at the time of receiving the SMS.

**Table 2**
Face mask useability questionnaire. Part 1 was based on questions used by Or et al [53]. **Part 2 consisted of nine questions developed for this clinical investigation.**

| Part 1 Question | Scoring | Part 2 Question | Scoring |
|---|---|---|---|
| Breathability | 1. Very unsatisfactory<br>2. Unsatisfactory<br>3. Average<br>4. Satisfactory<br>5. Very satisfactory | Difficulty walking | 1. Very difficult<br>2. Difficult<br>3. Neutral<br>4. Easy<br>5. Very easy |
| Heat | 1. Very unsatisfactory<br>2. Unsatisfactory<br>3. Average<br>4. Satisfactory<br>5. Very satisfactory | Difficulty driving | 1. Very difficult<br>2. Difficult<br>3. Neutral<br>4. Easy<br>5. Very easy |
| Tightness | 1. Very unsatisfactory<br>2. Unsatisfactory<br>3. Average<br>4. Satisfactory<br>5. Very satisfactory | Difficulty reading | 1. Very difficult<br>2. Difficult<br>3. Neutral<br>4. Easy<br>5. Very easy |
| Ease in talking | 1. Very unsatisfactory<br>2. Unsatisfactory<br>3. Average<br>4. Satisfactory<br>5. Very satisfactory | Difficulty working with a computer | 1. Very difficult<br>2. Difficult<br>3. Neutral<br>4. Easy<br>5. Very easy |
| Comfort on ears | 1. Very unsatisfactory<br>2. Unsatisfactory<br>3. Average<br>4. Satisfactory<br>5. Very satisfactory | Difficulty exercising | 1. Very difficult<br>2. Difficult<br>3. Neutral<br>4. Easy<br>5. Very easy |
| Overall comfort | 1. Very unsatisfactory<br>2. Unsatisfactory<br>3. Average<br>4. Satisfactory<br>5. Very satisfactory | Difficulty socialising | 1. Very difficult<br>2. Difficult<br>3. Neutral<br>4. Easy<br>5. Very easy |
| | | Physical safety concerns | 1. Extremely concerned<br>2. Moderately concerned<br>3. Somewhat concerned<br>4. Slightly concerned<br>5. Not at all concerned |
| | | Emotional impact | 1. Severe<br>2. Major<br>3. Moderate<br>4. Minor<br>5. Insignificant |
| | | Impact on appearance | 1. Very difficult<br>2. Difficult<br>3. Neutral<br>4. Easy<br>5. Very easy |

At the two week follow-up visit, wearing times of the vision correction and face masks were recorded and the QIRC, face mask usability questionnaire and subjective symptoms were once again recorded. Participants were then exited from the study.

Data were collected between November 2020 and April 2021.

### 2.3. Statistical analysis

Statistical analysis was conducted using JMP 14, Version 14.3 (SAS Institute Inc. Cary, NC, USA) using only right eye data to overcome issues related to inter-eye correlations [55]. Wearing times and visual acuity were compared between the two groups using a linear regression model as these variables were approximately normally distributed. No statistical analysis was performed for lens fit or slit lamp biomicroscopy as only one group wore lenses or underwent biomicroscopy at follow-up.

The QIRC overall score was compared between the two groups using a linear mixed model with participant ID as a random factor and score at the initial visit as a covariate. The use of Rasch scaling allows the overall QIRC score to be treated as a valid continuous variable evaluated with parametric statistical methods [52]. Individual QIRC questions were compared using a Mann-Whitney *U* test.

Individual questions from both parts of the face mask usability questionnaire, and ocular symptoms (0–100 VAS), were compared between the two groups using linear regression models, with the score at the initial visit as a covariate. This approach was merited as these variables respected an approximately normal distribution.

## 3. Results

Thirty-one participants attended for an initial visit and 30 successfully completed the study (one was considered ineligible due to additional personal protection being required in the workplace). Demographic details are shown in Table 3.

High contrast visual acuity was similar between the two groups at the initial and follow-up visits (all $F \leq 0.6$ and $p > 0.05$). Slit lamp biomicroscopy grades at the follow-up visit were all within normal clinical limits for successful contact lens wear. All participants showed acceptable lens fit at dispensing and follow-up, with 7% and 20%, respectively fitting 'optimally' (all parameters were graded as 0).

Table 4 shows the wearing times for the vision correction type and the face mask for the two groups. A statistically significant difference was found between groups for the vision correction wearing times with spectacles worn for a greater number of hours per day than contact lenses ($F(1,28) = 4.7$, $p = 0.04$). No differences were observed for the number of days per week the correction was worn or the number of comfortable hours per day of the correction (all $p > 0.05$). When face masks were worn, the contact lens group showed a significantly greater number of comfortable hours per day than the spectacle group ($F(1,28) = 5.1$, $p = 0.03$). No other differences in wearing times were observed between groups.

Overall QIRC scores at follow-up were significantly influenced by the QIRC score at the initial visit ($F(1,27) = 16.8$; $p = 0.0003$). A difference approaching statistical significance was found in the overall QIRC score at follow-up ($F(1,27) = 3.3$, $p = 0.08$), with slightly higher scores observed for the contact lens group compared with the spectacle group [Least square mean (95% CI): 47.2 (44.5–49.9) vs. 43.8 (41.1–46.5), respectively]. Fig. 2 shows the responses for each QIRC question for each vision correction group at both visits. At the initial visit, no significant differences were observed between the two groups for any individual question except for 'concern about the cost of unscheduled maintenance', for which the spectacle group showed a greater score than the contact lens group ($S = 281$, $p = 0.03$). At follow-up, statistically significant differences were observed for 'trouble doing outdoor activities e.g. playing games, playing sports?'($S = 222$, $p = 0.001$), 'trouble using a gym/doing keep-fit classes/circuit training, etc.?' ($S = 146$, $p = 0.03$) and 'felt able to do the things you want to do?' ($S = 260$, $p = 0.02$), with higher (better) scores observed each time for the contact lens group. Differences between groups for difficulty with glare ($S = 196$, $p = 0.08$) and 'concern about vision not being as good as it could be' ($S = 192$, $p = 0.08$) approached statistical significance, with the contact lens group showing higher (better) scores than the spectacle group.

**Table 3**
Demographics for each of the two study groups.

| Parameter | Contact lenses (n = 15) | Spectacles (n = 15) |
|---|---|---|
| Sex | 11 Female / 4 Male | 11 Female / 4 Male |
| Age (years) | 27.4 ± 5.8 (19 to 37) | 25.5 ± 5.3 (20 to 34) |
| Sphere (DS) | −0.92 ± 1.68 (-3.25 to + 3.00) | −1.53 ± 1.46 (-4.75 to + 0.75) |
| Cylinder (DC) | −0.33 ± 0.29 (-0.75 to 0.00) | −0.28 ± 0.25 (-0.75 to 0.00) |

**Table 4**
Vision correction and face mask wearing patterns at follow-up. Statistically significant results are shown in bold.

| Parameter | Contact lenses (n = 15) | Spectacles (n = 15) | Statistics |
|---|---|---|---|
| Vision correction use | | | |
| Days per week | 6.6 ± 0.6 | 6.8 ± 0.6 | $F(1,28) = 0.8$, $p = 0.37$ |
| Hours per day | 10.1 ± 2.3 | 12.2 ± 3.0 | $F(1,28) = 4.7$, **$p = 0.04$** |
| Comfortable hours per day | 8.7 ± 3.0 | 10.0 ± 4.6 | $F(1,28) = 0.8$, $p = 0.38$ |
| Face mask use | | | |
| Days per week | 5.8 ± 1.1 | 5.8 ± 0.9 | $F(1,28) = 0.0$, $p = 0.93$ |
| Hours per day | 3.8 ± 2.7 | 3.7 ± 2.1 | $F(1,28) = 0.1$, $p = 0.91$ |
| Comfortable hours per day | 3.4 ± 2.8 | 1.5 ± 1.6 | $F(1,28) = 5.1$, **$p = 0.03$** |

Fig. 3 shows the subjective ratings for the first part of the face mask usability questionnaire for both groups at follow-up. There were statistically significant differences between the two groups, with the contact lens group showing higher (better) ratings for the following: 'breathability' ($F(1,25) = 4.4$, $p = 0.047$), 'heat' ($F(1,27) = 9.4$, $p = 0.005$) 'comfort on ear lobes' ($F(1,27) = 5.1$, $p = 0.03$) and 'overall comfort' ($F(1,27) = 9.8$, $p = 0.004$). Subjective ratings at follow-up were significantly influenced by the initial ratings for 'comfort on earlobes' ($F(1,27) = 25.0$,$p < 0.0001$) and 'ease in talking' ($F(1,27) = 6.5$, $p = 0.02$).

Higher subjective ratings were also observed in the contact lens group compared with the spectacle group for the second part of the face mask usability questionnaire: 'walking' ($F(1,26) = 36.8$, $p < 0.0001$), 'driving' ($F(1,8) = 34.4$, $p = 0.0004$), 'reading' ($F(1,27) = 34.4$, $p = 0.0004$), 'computer use' ($F(1,24) = 10.6$, $p = 0.03$), 'exercising' ($F(1,16) = 46.4$, $p < 0.0001$) and 'socialising' ($F(1,26) = 46.4$, $p < 0.0001$) (Fig. 4). No significant differences were observed for 'physical safety concerns' ($F(1,27) = 2.5$, $p = 0.12$), 'emotional impact' ($F(1,27) = 2.9$, $p = 0.10$) or 'impact on personal appearance' ($F(1,27) = 2.0$, $p = 0.17$).

Subjective VAS scores for the nine ocular-related symptoms at the follow-up visit are shown in Fig. 5. The contact lens group showed significantly greater scores compared with the spectacle group for distance vision ($F(1,27) = 8.7$, $p = 0.007$), near vision ($F(1,27) = 4.9$, $p = 0.04$), glare ($F(1,27) = 10.8$, $p = 0.003$), fogging ($F(1,27) = 153.0$, $p < 0.0001$), restricted field of view ($F(1,27) = 16.1$, $p = 0.0004$), and peripheral blur ($F(1,27) = 8.1$, $p = 0.01$). No differences were observed between groups for dryness, comfort or redness (all $p > 0.05$). Subjective VAS scores at the follow-up visit were significantly influenced by the initial VAS score for peripheral blur ($F(1,27) = 17.7$, $p = 0.0003$).

SMS responses to prompts asking for visual performance scores showed a statistically significant difference in favour of contact lenses ($4.69 \pm 0.55$ vs. $2.80 \pm 1.32$; $F(1,25) = 24.4$, $p < 0.0001$).

## 4. Discussion

This work has established that various subjective ocular and task-related parameters associated with wearing a face mask are better when contact lenses versus spectacles are used for vision correction.

For overall QIRC score, there were no statistical differences between the two groups although the analysis did show a difference approaching

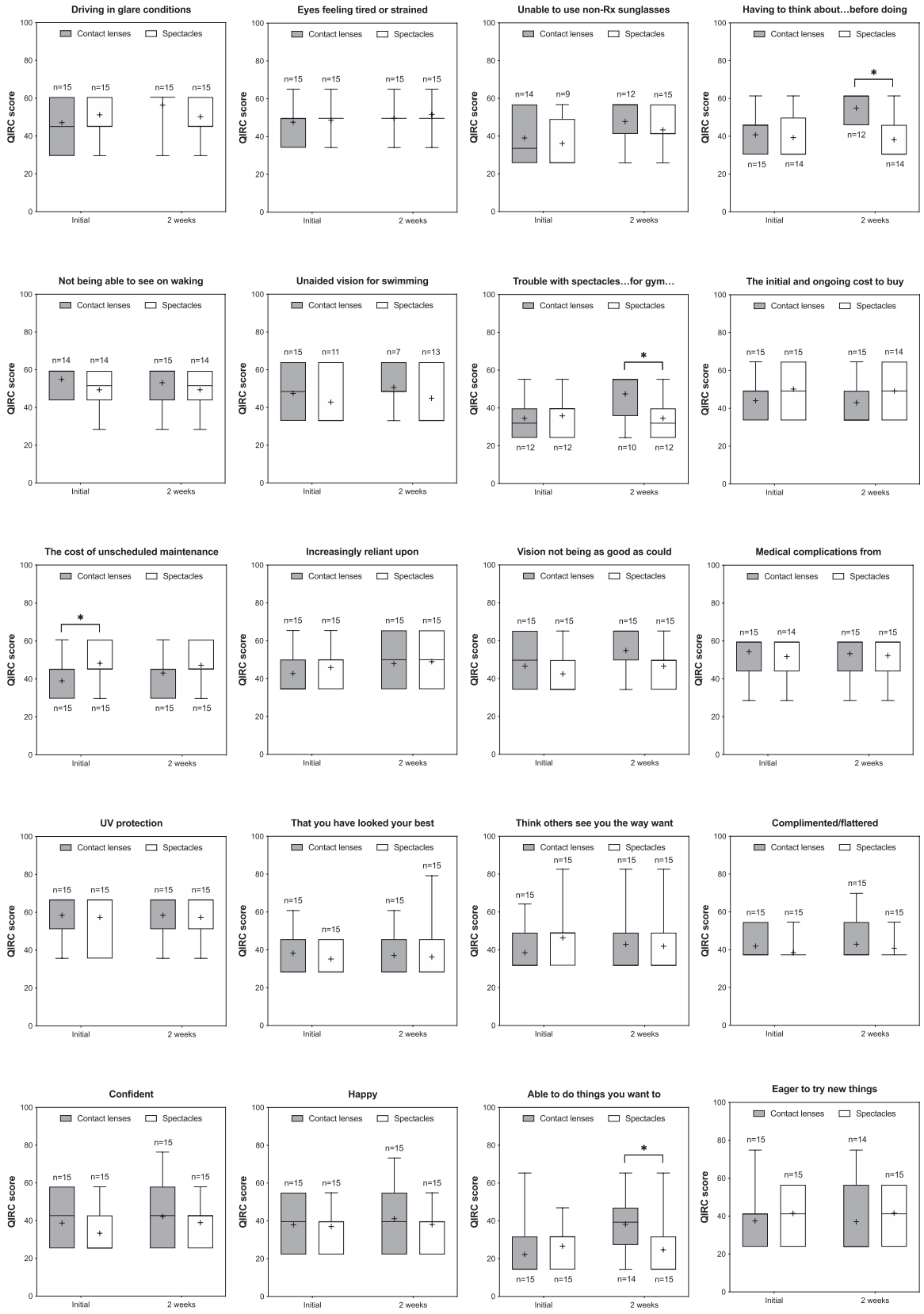


**Fig. 2.** Box and whisker plots showing responses to individual QIRC questions.

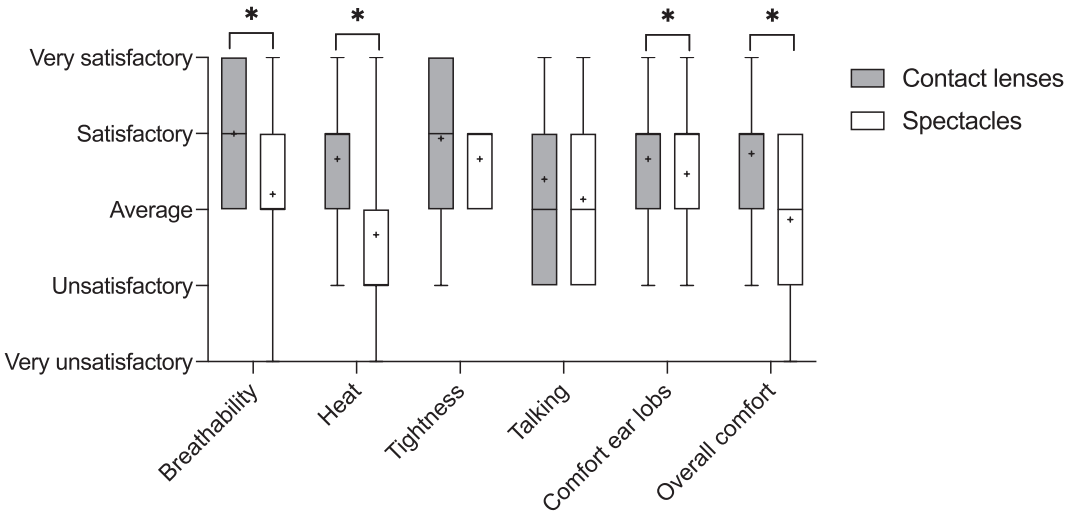


**Fig. 3.** Subjective ratings for the face mask usability questionnaire (Part 1) at follow-up.

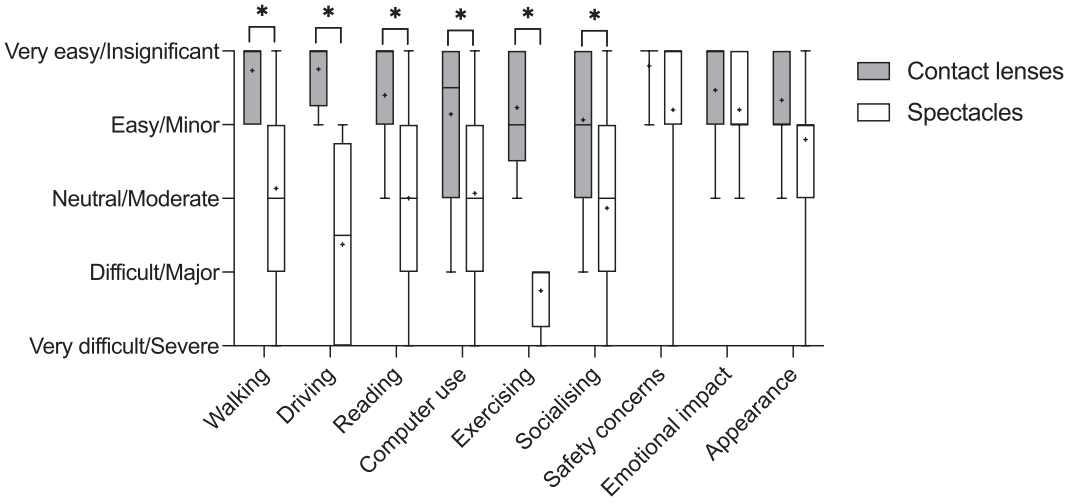


**Fig. 4.** Subjective ratings for the face mask usability questionnaire (Part 2) at follow-up.

statistical significance in favour of the contact lenses. Although this questionnaire evaluated both mask-wearing and non-mask-wearing periods, it is reasonable to assume that the mask-wearing will have influenced the responses since they were worn on the majority of days during the study. Questions relating to 'trouble doing outdoor activities', 'trouble doing gym/keep fit' and 'able to do things' were scored significantly higher for the contact lenses compared to the spectacles. Although no adjustments were made for the requirement for multiple statistical comparisons, the observation that all the identified differences related to activity-type characteristics is very unlikely to occur by chance and strongly suggests that such results accurately represent the true relative performance of the two vision correction modalities studied.

Interestingly, questions about personal appearance and confidence were not different between the two groups which is in contrast to other work showing a positive impact of contact lenses in relation to these aspects [56,57]. The reasons for the differences between the present work and that of others probably relate to the unusual times at which this investigation was carried out or that the participants were only motivated to wear the contact lenses for this study. Data were collected between November 2020 and April 2021 - a period in the UK which spanned two lockdowns during the COVID-19 pandemic. During this time, people may have been less concerned about their appearance as a result of reduced socialising. Additionally, wearing a face mask when in contact with others could have reduced the feelings of impact of spectacles on appearance further which is supported by evidence which shows that established contact lens wearers wore their lenses less than normal during the pandemic.[58,59]

No previous work has compared the use of any kind of face mask with the two forms of vision correction used here. Data from the first part of the usability questionnaire showed that four of the six parameters investigated were significantly better with the contact lenses: breathing, heat, comfort on ear lobes and overall comfort. Breathing may have been more problematic with spectacles in an attempt to prevent fogging by disrupting normal breathing patterns (e.g. holding the breath, trying to redirect it or taking more shallow breaths). The perception of feeling more heat when wearing spectacles is interesting and could have been caused by the exhaled breath lingering for longer periods behind the spectacles, having the effect of increasing the humidity inside or outside the mask. [60] The finding that contact lenses were more comfortable in relation to the ears is expected since they remove the necessity for any interaction with the ears at all and additionally, any interaction of the mask loops with the spectacle frame arms. Better 'overall comfort' was observed in the contact lens wearers and is likely to reflect the overall differences which were seen in all of the questionnaires used in this work.

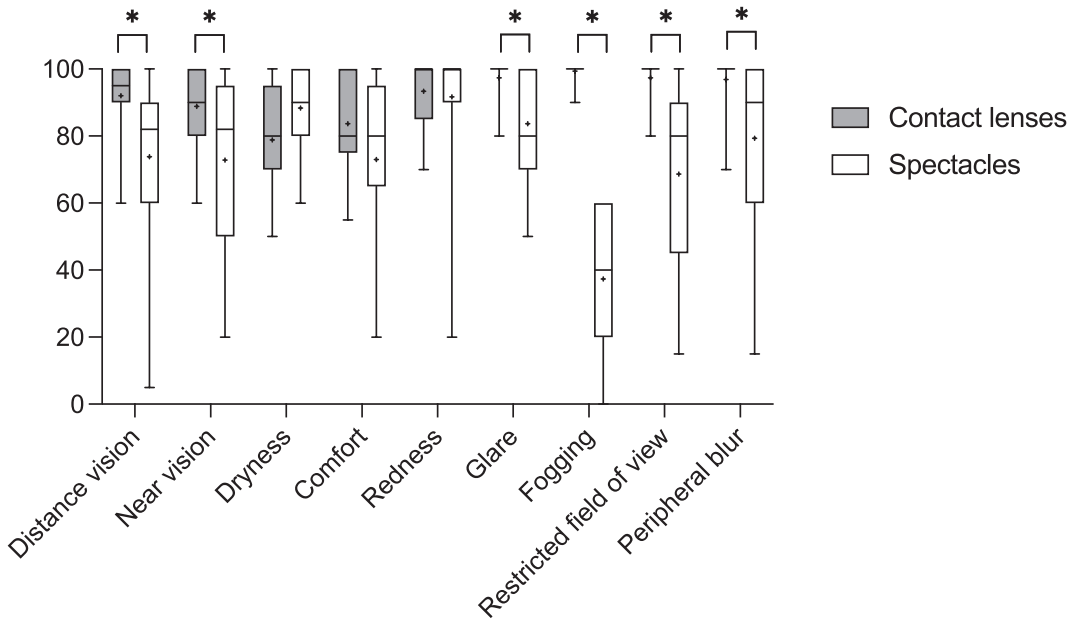


**Fig. 5.** Subjective VAS scores on ocular symptoms at follow-up.

An additional nine questions were developed for this work and used in the second part of the face mask usability questionnaire. Six of the nine parameters investigated in this part were better with the contact lenses (none was better with spectacles). Levels of difficulty in walking, driving, reading, computer use, exercise and socialising were considered less difficult in the contact lens group. These responses are all likely to have been driven in the main by visual symptoms (as indicated by the ocular symptoms VAS results) which include glare, fogging and restricted field of view which were worse in the spectacle group. Symptoms of increased difficulty with exercising could also have been attributed to the higher levels of heat and difficulty breathing experienced by the spectacle group. There were no differences between the two vision corrections for 'physical safety', 'emotional impact' and 'personal appearance'. The latter two symptoms are unlikely to be vision-driven and the finding of no difference between the groups for 'personal appearance' is once again in contrast to results of previous work which has shown that fitting a spectacle wearer with contact lenses positively increases their feelings in this particular aspect [56,57].

No differences were established between the two correction types for 'physical safety'; this question was added to the second part of the face mask usability questionnaire in order to investigate if visual problems in particular caused anxieties in potentially hazardous situations such as driving and walking. Vision was clearly established in this work to be better with contact lenses overall, so it might be that in most 'safety' situations (e.g. driving), any face mask would often be deliberately removed to maintain good vision.

Data for the ocular symptoms using the 0–100 VAS scales showed differences in favour of the contact lenses in six out of the nine symptoms investigated which included all of the vision symptoms (glare, distance vision, near vision, fogging, restricted field of view and peripheral blur). None of these parameters was better in the spectacle group. In general, the magnitude of these differences between the two groups is around 20–30 units which is highly clinically meaningful. For 'fogging' this difference was >60 units which is an unprecedented magnitude of difference when this type of grading scale is used. [61–63] The result strongly supports anecdotal reports which describe fogging as the most troublesome symptom when using a face mask with spectacles. Reduced distance vision, restricted field of view and peripheral blur all indicate the potential for safety issues with a face mask/spectacle combination.

No differences were seen for the non-vision related symptoms of 'dryness', 'comfort' and "redness' between the two groups. Discomfort and dryness can be significant problems in established contact lens wearers [64–67], and vision problems are commonly cited as reasons for discontinuation in new weares of spherical single vision lenses [68,69], so it is noteworthy that similar scores for dryness and discomfort for the two correction types are reported here, albeit these were neophytes. There are reports in the literature of a new phenomenon termed 'mask-associated dry eye or 'MADE' [29,30] where it has been proposed that face masks (particularly 'loose fitting' surgical face masks) can channel exhaled air through the top of the mask and then over the surface of the eye which can then in turn affect the tear film stability as a result of increased evaporation. This work suggests that any MADE-related symptoms are similar when contact lenses or spectacles are used with face masks; that is, there is no obviously 'protective' effect from using spectacles.

SMS responses showed that vision performance was significantly better in the contact lens compared to the spectacle group, in all likelihood due to all the reasons outlined above. The advantage of SMS messaging is that participants are able to record their responses in real time without having to recall their opinion as they had to do for the other questionnaires at the follow-up visit. It is important to note that the SMS may have been received when a mask was not being worn, so these responses may not always have been representative of the vision between the two groups when the mask was being worn.

The limitations of this work are that the participants were un-masked to their 'treatment' group. In this randomised controlled investigation it was not possible to mask a participant to the fact that they were being fitted with contact lenses, but it should still be taken into consideration that the contact lens wearers may have been biased favourably towards their 'new' vision correction, especially when used in conjunction with a face mask. The investigators also were not masked to the participant group, but this is thought to have a reduced effect on any bias, given that the main measures of interest in this work were the subjective participant scores. Additionally, this study took place over a short, two week period and it may not be appropriate to extrapolate these findings to a longer duration of wear. However, anecdotal reports suggest that vision problems with spectacles and face masks are an ongoing problem for many people. The participants who were randomised to wear the contact lenses adjusted well to their new vision correction as demonstrated by the fact that their contact lenses were worn for a similar number of days per week as those in the spectacle group and lenses were worn for over 10 h per day on average. Face masks were worn for a similar period

of time over the study for the two groups. Participants would also have been carrying out different activities for different lengths of time and data on this was not collected during the study.

The data collected in this work are only valid for the particular type of surgical face mask investigated. Other masks which for example fit more snugly to the facial contours such as FFP2 or FFP3 (N95 or N99) masks may produce different results with either vision correction. Similarly, a different brand of contact lens or one which is not a daily disposable lens could also produce different results.

## 5. Conclusions

This work supports anecdotal reports that contact lenses (in neophytes) are a better vision correction option than spectacles when used in conjunction with a face mask. Participants reported a range of benefits to the contact lens/face mask combination for vision-related symptoms, breathing and heat-related symptoms and a number of day-to-day activities including walking, driving and exercising. Any difficulty in wearing a face mask is likely to deter the user from wearing the mask correctly or worse, to remove it altogether, which would lead to lower levels of protection. This is particularly relevant to healthcare workers who need to be able to wear their masks correctly, often for long periods in order to comply with clinical standards around infection control. All of the benefits relating to the contact lenses are likely to result in improved adherence to face mask use. Overall, the findings of this work suggest that where possible, contact lenses should be the preferred vision correction option for people using face masks.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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