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A Comparison of Spectacles Purchased Online and in UK Optometry Practice

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ABSTRACT

Purpose. To compare spectacles bought online with spectacles from optometry practices.

Methods. Thirty-three participants consisting of single vision spectacle wearers with either a low (N = 12, mean age 34 ± 14 years) or high prescription (N = 11, mean age 28 ± 9 years) and 10 presbyopic participants (mean age 59 ± 4 years) wearing progressive addition lenses (PALs) purchased 154 pairs of spectacles online and 154 from UK optometry practices. The spectacles were compared via participant-reported preference, acceptability, and safety; the assessment of lens, frame, and fit quality; and the accuracy of the lens prescriptions to international standard ISO 21987:2009.

Results. Participants preferred the practice spectacles (median ranking 4th, IQR 1–6) more than online (6th, IQR 4–8; Mann-Whitney U = 7345, $p < 0.001$) and practice PALs (median ranking 2nd, IQR 1–4) were particularly preferred (online 6.5th, IQR 4–9, Mann-Whitney U = 455, $p < 0.001$). Of those deemed unacceptable and unsafe, significantly more were bought online (unacceptable: online 43/154 vs. practice 15/154, Fisher's exact p = 0.0001; unsafe: online 14/154 vs. practice 5/154, Fisher's exact p = 0.03).

Conclusions. Participants preferred spectacles from optometry practice rather than those bought online, despite lens quality and prescription accuracy being similar. A greater number of online spectacles were deemed unsafe or unacceptable because of poor spectacle frame fit, poor cosmetic appearance, and inaccurate optical centration. This seems particularly pertinent to PAL lenses, which are known to increase falls risk. Recommendations are made to improve both forms of spectacle provision. (Optom Vis Sci 2016;93:1196–1202)

Key Words: spectacles, online, practice, progressive addition lenses, PALs, acceptance, safety

In most developed countries, spectacles are purchased via optometry practices. The spectacles are produced to order, and then verified at the practice to ensure frame quality and optical tolerances set by national/international standards.[1] This is followed by collection and final fitting by the practitioner. Spectacles are now increasingly sold online, with approximately 6% of all prescription spectacles in the UK purchased via the Internet in 2015.[2] In this situation, the purchaser is responsible for the correct inputting of any measurements required to fulfill the order, and the spectacles are delivered without the traditional dispensing process. An assessment of the quality of online spectacles in comparison with those dispensed in optometry practice is important given the likely increase in this purchase method and the possible adverse effects on patients if the spectacles are not supplied correctly.[3,4] This would seem to be particularly important for the provision of bifocals and progressive addition lenses (PALs), which can increase the risk of accidents and falls in elderly patients[5–7] and which current standards suggest require careful fitting.[8]

The study aims were to compare the participant-reported preference, acceptability, and safety; the lens prescription accuracy; and the lens, frame, and fit quality of spectacles bought online compared to spectacles dispensed within optometry practices. Although the quality of online spectacles has been assessed,[9] this is the first report to compare online spectacles and optometry practice spectacles.

METHODS

Participants were recruited by e-mail invitation from the staff and students of the University of Bradford, England, UK. Three

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separate groups of participants were recruited based on refractive characteristics: single vision (SV) low prescription (Rx) (<±5 D in both eyes), single vision high Rx (≥±5 D in at least one eye), and presbyopic participants who were dispensed with PALs. Participants were only included if they had no ocular pathology, were an adapted spectacle wearer, and had an up-to-date prescription to which their current spectacles were made. Optometry staff and final year students were excluded as were anybody with multiple falls risk factors. Ethical approval was gained from the University of Bradford ethics committee (application number E393), and all participants gave informed written consent after the study had been fully explained. The guidelines of the Declaration of Helsinki were followed.

In June 2014, the search term "online spectacle retailers" was entered into five search engines (Google, Bing, Yahoo, Ask, and AOL) and the top 15 websites from each search engine were recorded. Those online retailers who did not appear to have a UK base or were part of an optometry/optician company were excluded. From those remaining, a list of the top 10 most easily accessed websites was determined. Participants were randomly assigned five of these websites and were instructed to order a pair of spectacles from each. They were also instructed to purchase spectacles from five optometry/optician practices of their choice, which had to include (to approximately represent market share) one supermarket; one Specsavers, which is the largest chain of optometry/optician practices in the UK; one other chain (e.g. Boots, Vision Express); and one independent practice. They were randomly assigned to purchase either all their online or all their optometry/optician spectacles first and were given a budget depending on the typical cost of the type of spectacles they required. All optometry/optician practices visited were in West Yorkshire, UK; the online websites are inherently available throughout the UK (and internationally).

Once all the spectacles from a participant were purchased, they were collected and coded by members of the research team who were not involved in any subsequent assessments. Any mention of a website or practice name on the spectacle frames was masked and the spectacle cases were randomly swapped in an attempt to limit the participant's and researcher's knowledge of the origin of the spectacles. The spectacles were then returned to the participant who was asked to wear each pair for at least 2 hours over a 2- to 3-day period, and subsequently complete a questionnaire regarding vision, comfort, fit, and how acceptable and safe they felt the spectacles were (see Appendix A, available at http://links.lww.com/OPX/A256). The participants subsequently attended a final meeting at the eye clinic of the University of Bradford, where the visual acuity, ocular muscle balance, and fit and quality of the spectacle frames and lenses were assessed. Once all spectacles had been evaluated, any that were within international tolerance levels were given to the participants in return for their participation. Participant recruitment, spectacle purchase, and spectacle assessment took place between November 2014 and November 2015.

Primary Outcomes

Participant Preference and Indication of Acceptability and Safety

The most appropriate assessment of spectacles is whether patients find them acceptable or not,[10,11] which is partly based on whether they are symptom-free.[12] The participants provided information regarding their preference (they ranked the spectacles from 1st to 10th) and whether the spectacles were unacceptable and/or unsafe (Appendix A, available at http://links.lww.com/OPX/A256). Where spectacles were classed as unacceptable or unsafe by the participants, the main reason(s) for the problem(s) was determined by agreement between the authors using all other data obtained.

Distance (and near for PALs) binocular visual acuity (VA) and ocular muscle balance measurements were undertaken with the participant wearing each pair of spectacles in a randomized order. Distance VA was measured using a high-contrast Bailey-Lovie distance chart in an ETDRS illuminator cabinet at 4 m, using three separate charts in a random order.[13] Near VA was measured using one of five Bailey-Lovie word reading charts[7] in a random order. Distance and near horizontal and vertical heterophorias were measured using a modified Thorington chart[14] and the oblique tangent scale on a near Freeman unit, respectively.

Lens and Frame Quality and Frame Fitting Assessment

Assessments of the fit of the frames and the quality of both the lenses (e.g. fitting within the frame, looseness, chips, scratches, etc.) and the frames (e.g. no metal reinforcement in sides, rim misshaped, poor quality hinges, etc.) as good, fair, or poor were made by an experienced dispensing optician who was blind to the origin of the spectacles.

Assessment of Lens Prescription

The lens prescriptions were measured using a manual focimeter/lensometer (LM-350; Nidek, Aichi, Japan) and their accuracy assessed using the International standard ISO 21987:2009 for parameters where the ordered value was known.

The International standard (ISO 21987:2009) is to be used to assess accuracy against an order, but we did not know what OCD (for practice spectacles) and fitting height (for all spectacles) had been ordered. Instead, interpupillary distance for all participants and fitting heights for all PALs were recorded by an experienced dispensing optician, and these were used to assess accuracy. As interpupillary distance and fitting height measurements would differ between clinicians, we increased the tolerance limits for these measurements. Binocular (for SV spectacles) and monocular (for PALs) interpupillary distances (PD) were measured using a digital pupillometer (Essilor, Paris, France). The PAL fitting heights were measured with the participant looking at a distance object while a dot was placed on the lens at the pupil center. The heights were recorded as the vertical measurement from the dot to the lower tangent of the lens. Although measurement of PD by pupillometer is reliable, it can give measurements up to a millimeter smaller than those produced by Viktorin's method.[15] As we were unaware of the method used to measure PD by those ordering the spectacles, for the PALs a more lenient tolerance (ISO 21987:2009 is ±1 mm of that ordered) of within ≤±2 mm of the monocular PD was used. The international standard 21987:2009 requires fitting heights to be within 1 mm of that ordered, but we were comparing the fitting height on the spectacles provided with

the fitting height determined by the study dispensing optician, both of which could be in error. Inter-examiner repeatability of fitting height measurements for PALs suggests an error of approximately ±2 mm,[8] so that a more lenient tolerance of ≤±4 mm of the fitting height measured was used.

Data Analysis

We used the participants' reported assessment of acceptability as the main outcome measure to determine approximate sample size. We assumed a 5% unacceptable figure for spectacles bought from practices based on Cockburn's figure for patients returning with both dispensing and refraction-related complaints to a suburban optometry practice.[3] We estimated a 15% unacceptable figure for online spectacles based on Citek and colleagues' 28.6% "optical parameter failure rate" of 156 online spectacles.[9] We assumed that practice dispensed spectacles would be superior to online (similar to Citek et al.[9]) given the additional dispensing function, so that we used one-tailed analyses throughout and in the power sample size calculation. For 90% power and an alpha of 0.05, we calculated a suggested sample size of 172 per group (Stata 13.1; StataCorp, College Station, TX). With a 15% increase for potential participant dropout, our target sample size was 396.

Data were analyzed using SPSS version 20 (IBM, Armonk, NY) and Stata 13.1. Participant rankings, spectacle prescription, and cost data were not normally distributed (Kolmogorov-Smirnov tests) and are described in terms of medians and interquartile ranges (IQR), with comparison of ordinal data undertaken using either two-tailed Kruskal-Wallis or Mann-Whitney tests. Comparisons of categorical data between practice and online spectacles were analyzed using one-tailed Fisher's exact tests.

RESULTS

Fig. 1 provides a breakdown of the participants recruited and spectacles analyzed including reasons for non-completion of the study. Three hundred nine spectacles were ordered in total, with 154 from online suppliers. Of the 155 pairs of practice spectacles, 21% were from a supermarket, 46% from a commercial chain of optometry/optician practices, and 33% from an independent optometric practice.

Participant Preference and Indication of Acceptability and Safety

Participants ranked the practice spectacles significantly higher than the online spectacles with median rankings (IQR) of 4th (1–6) for practice spectacles vs. 6th (4–8) for online (Mann-Whitney U = 7345, $p < 0.001$). Fifty-eight (19%) of the 308 pairs of spectacles were classed as unacceptable by participants and substantially more of the online spectacles were deemed unacceptable (43/154 vs. 15/154; Fisher's exact p = 0.0001). The reasons they were deemed unacceptable are shown in Table 1.

Nineteen (6%) of the 308 pairs of spectacles were classified as unsafe and more of the online spectacles were deemed unsafe

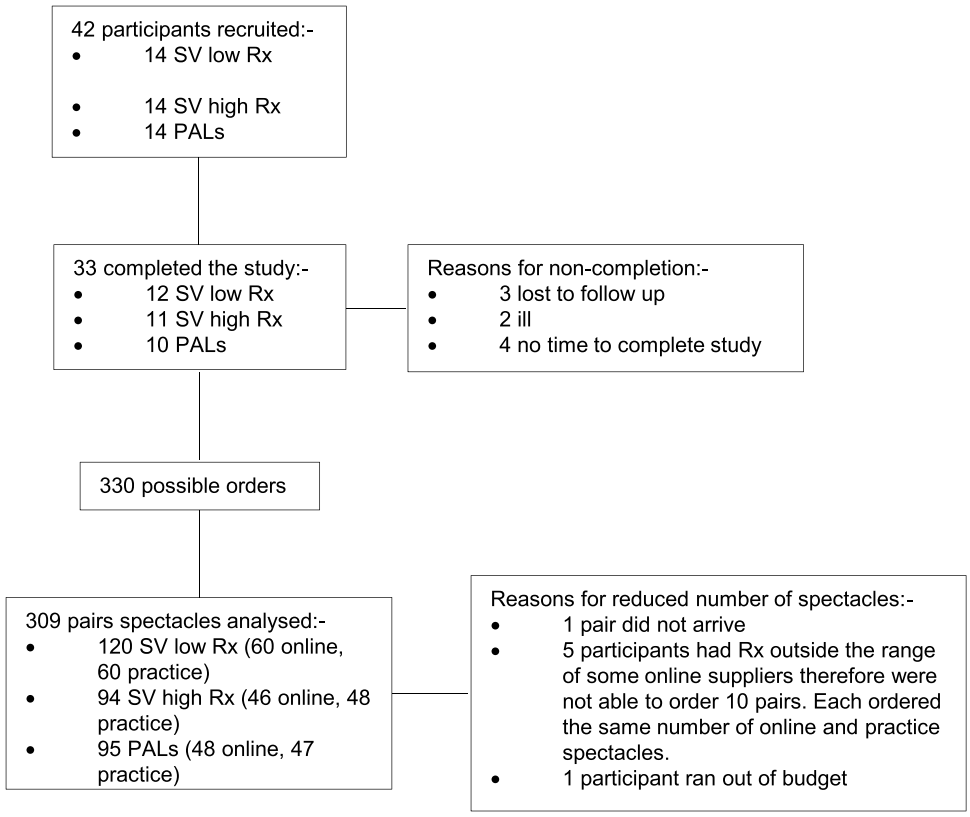

FIGURE 1.

Breakdown of participants recruited and spectacles analyzed including reasons for non-completion of study. SV, single vision; Rx, refractive correction; PALs, progressive addition lenses.

TABLE 1.
Main reasons (as determined by the authors from all the available data) that 58 pairs of spectacles were deemed ''unacceptable'' by participants and 19 pairs deemed ''unsafe'' (eight pairs of spectacles had multiple reasons)

	Unacceptable		Unsafe	
Etiology	Online	Optometry practice	Online	Optometry practice
Fit and/or appearance	15	5	2	1
Poor fit causing symptoms	10	4	4	1
Optical centration distance outside tolerance	11	2	4	1
Fitting heights outside tolerance	6	2	3	1
Refractive correction outside ISO 21987:2009	4	2	3	2
Vertical prism	2		1	
No obvious reason	1	2	1	
Total	43	15	14	5

(14/154 vs. 5/154; Fisher's exact p = 0.03). The reasons they were deemed unsafe are shown in Table 1.

The practice PALs were much preferred compared to the online PALs (practice median ranking 2nd, IQR 1st–4th vs. online ranking 6.5th, IQR 4–9; U = 455, $p < 0.001$). Of the 95 PALs, more online PALs were deemed unacceptable (11/48) compared to practice PALs (3/47, Fisher's exact p = 0.022) with a similarly small number deemed unsafe (4/48 online vs. 1/47 practice, Fisher's exact p = 0.19). The majority of the online PALs were deemed unacceptable or unsafe because of poorly fitting lenses or poorly fitting frames.

Lens and Frame Quality and Frame Fitting Assessment

Thirty-three (11%) of 308 (one pair was not assessed) pairs of spectacles had lens quality categorized as poor (19 online, 14 practice; Fisher's exact p = 0.18) and 16 (5%) of 308 (12 online, 4 practice; Fisher's exact p = 0.035) had frame quality categorized as poor. Cost of spectacles was related to the quality of both the lenses ($\chi_2^2 = 8.2$, p = 0.01) and frames ($\chi_2^2 = 20.8$, $p < 0.001$), with those classed as poor quality being significantly cheaper in price than those classed as satisfactory or good. The average cost of the online spectacles was significantly lower (median $96, IQR $56–164) than the practice spectacles (median $165, IQR $105–255, U = 6451, $p < 0.001$). Frames were better fitted when from practices compared to those purchased online (practice N = 154; 66 poor, 43 satisfactory, 45 good; online N = 153, 85 poor, 48 satisfactory, 20 good; $\chi_2^2 = 12.3$, p = 0.002).

Assessment of Lens Prescription

Twenty-one (7%; 11 online, 10 practice) of the 309 pairs of spectacles failed ISO 21987:2009 tolerances (Table 2).

When the OCDs of the low and high Rx spectacles were compared to the participants' PD measurements, 39 (18%) of the 214 pairs included horizontal prism outside study tolerance limits (not necessarily outside ISO 21987:2009). As would be expected from the linear relationship between lens power and prism power (Prentice's Rule) errors were higher for the high Rx spectacles (23 or 25%) compared to the low Rx spectacles (16 or 13%; Fisher's exact p = 0.029). A significantly higher proportion of those failing were from online retailers (28/214 vs. 11/214; Fisher's exact p = 0.003). Fig. 2 illustrates the horizontal prism imbalance for the high Rx SV group. When the ordered PD data for the online spectacles were substituted in this analysis, 29 of 204 (14%) pairs of SV spectacles (one participant was unable to provide the PD information from the orders) had horizontal prism imbalance outside study tolerance limits. Nineteen (66%) were from online suppliers, which was not significantly different from practice SV spectacles (19/204 vs. 10/204; Fisher's exact p = 0.06). Fifteen (16%) of 94 pairs of PALs (one pair could not be marked up) had the horizontal and/or vertical position of the fitting point outside study tolerance limits (11/47 online vs. 4/47 practice; Fisher's exact p = 0.044). Of those spectacles ordered from practices, 15% (5 of 33) from supermarkets, 20% (14 of 71) from optometry chains, and 10% (5 of 51) from independents were outside tolerances. There was no statistically significant difference between these three groups ($\chi^2 = 2.23$, p = 0.33).

DISCUSSION

Principal Findings

Participants preferred practice spectacles, ranking them higher on average than those bought online (median 4th vs. 6th ranking on a 1st–10th scale), and 79% (26/33) stated that they would purchase their next pair of spectacles from optometry/optician practices. Significantly more online spectacles (43/154, 30%) were classed as unacceptable by participants than practice spectacles (15/155, 10%) and likely due to unacceptable fit and appearance (Table 1). Seventy-eight percent of those perceived as unsafe came from online suppliers and for half of those the problem was due to the fit of the frame rather than the prescription accuracy of the lenses. Previous studies have shown that

TABLE 2.
Reasons for spectacles being classed as outside ISO 21987:2009[1]

Reason for failure	Online	Optometry practice
Cylinder axis outside tolerance	6	2
Back vertex power outside tolerance	1	4
Vertical prism imbalance	3	1
Cylinder power outside tolerance		1
Near addition power outside tolerance		1
Lenses swapped right and left		1
Incorrect transposition	1	

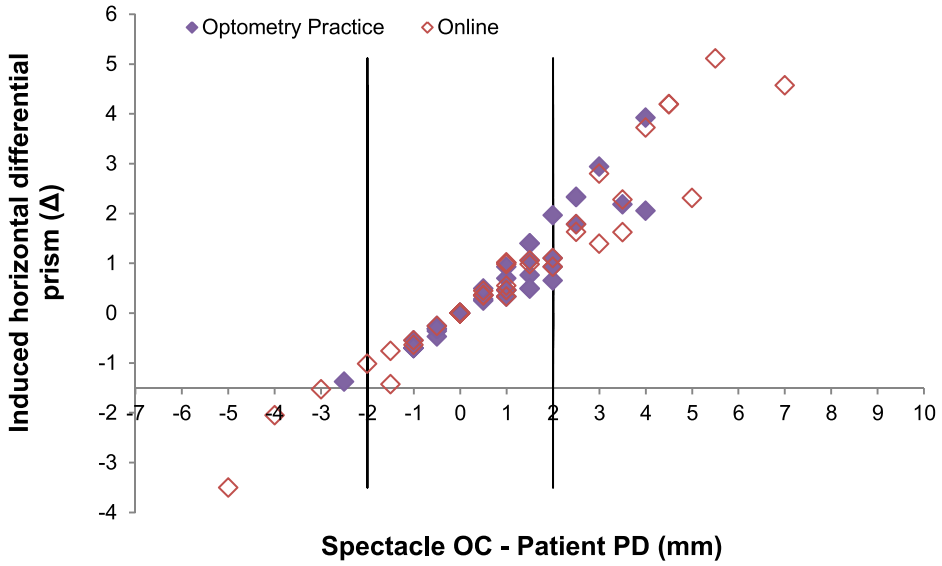

FIGURE 2.

Difference between the participants' interpupillary distance (PD) and the optical centration (OC) distance of each pair of spectacles versus the amount of horizontal differential prism induced by this difference for the single vision high refractive correction group. Spectacles from online suppliers and optometry practice are shown separately. The solid black lines indicate the tolerances of ±2 mm. Positive induced prism is base in.

the quality of life impact of spectacles is driven by factors such as cost, appearance, and convenience with less emphasis on vision than ophthalmic clinicians might believe.[16,17] The online spectacles included a larger number of frames categorized as poor quality (8%, 12/154), although lens quality was similar. This difference in frame quality is partly linked to the lower cost of online spectacles (median $96 vs. $165) given that frame quality improved with cost. The glazing of the lenses to the frames was of a similar quality in both online and practice spectacles as the number of errors outside tolerance were similar when the ordered centration was used as the standard. Online spectacles were much superior when compared to the quality of "ready reading" spectacles, which a previous study has shown include ~50% with optical errors and that about a third of higher powered readers have unwanted vertical prism.[18] Again, this is likely related to cost, given that the cost of ready readers is substantially lower (median about $6,[18]) than online custom-made spectacles (median $96). Despite satisfactory glazing, in many cases the ordered centration for online spectacles was incorrect (Fig. 2), as websites typically use an average value or recommend that interpupillary distances are measured by the patient themselves (in a mirror) or by a friend and these measurements are often inaccurate.[19]

PALs from practices were much preferred (median ranking 2nd) than those purchased online (6.5th) and more online spectacles were considered unacceptable. There were different approaches taken to the PD and fitting heights used for PALs by online retailers.

These measurements are important to ensure that the centration point of the lens is placed in front of the patient's pupil to avoid areas of distortion and blur. The various approaches to PDs have been discussed. Seven of the ten websites make no mention of the importance of PAL fitting height and presumably provide an average value. The other three attempt to gauge an appropriate height by taking measurements from a previous pair of PALs or by obtaining a photograph of the patient wearing the chosen frame or by asking the patient to measure the pupil heights within the frame. All six of the PAL fitting heights that were beyond the lenient 4 mm tolerance were from online retailers that provided no information regarding this measurement (6/33, 18%). However, fitting of PALs from practices was not perfect and 3 of 47 (6%) were considered unacceptable and 4/47 (9%) included poor centration.

Study Strengths and Weaknesses

The study strengths include the self-reported assessments of preference, acceptability, and safety. This is the first study to compare spectacles dispensed from optometry/optician practices with those bought online. The weakness included the significant amount of cooperation asked of participants and nine were lost to follow-up (Fig. 1). Although the target number of 172 per group was not met due to the higher-than-expected participant dropout of 21%, the significance of the statistical analyses suggests that the sample size allowed an adequate comparison. Given this issue, the limitation of the 2-hour participant assessment of each pair of spectacles is deemed a reasonable decision, as any increase (to say 2 days per pair of spectacles[11]) would likely have increased participant dropout further. We suggest that future studies recruit more participants and ask them to purchase fewer spectacles each. A total of 97% of our participants had bought their previous spectacles via an optometry/optician practice, and this may have led to a more positive reaction to spectacles bought from practices due to confirmation bias[20]: the participants might prefer the practice dispensed spectacles (and particularly those from the practice they have previously used) to (subconsciously) confirm that they had made the correct choice in previously attending that practice (or type of spectacle provider). We would suggest that future studies should ensure that individual participants do not obtain spectacles from any practice or website they have used previously. In addition, participants were allowed to order any style of frame from the different providers, and this would likely

have allowed them to link certain frames with certain providers. Participants would have been better masked if we had required them to only order frames of one certain style and color (although this may have limited participant recruitment and retention). Other limitations include the lack of lens impact testing or a formal assessment of the purchasing system, such as the time taken for the spectacles to be ready for collection.

Comparison with Other Studies

As far as we are aware, there is only one previous assessment of online spectacles reported in the literature. Citek et al.[9] evaluated the optical quality of spectacles bought online in the USA. They assessed 154 pairs of spectacles (exactly the same number as the current study) and reported that 28.6% of online spectacles failed the study tolerances,[15] which is similar to the 30% figure from the current study. The Citek et al.[9] study was limited by a lack of comparison with the traditional spectacle purchase system (the implication being that it would show a minimal failure rate), lack of assessments of acceptability to the participant, frame quality, frame fit, or optical centration. However, it should be noted that we did not include impact testing in our assessment, and Citek and colleagues found that 23% of online lenses failed impact testing.[9]

Possible Implications for Spectacle Providers and Policymakers

The online spectacle results are generalizable to the whole of the UK, and although the practice spectacle results are only strictly generalizable to the West Yorkshire area, they are likely to be similar to all optometry/optician provision throughout the UK except for Scotland, where the NHS provision of sight tests is very different. The study indicated that participants preferred spectacles from optometry/optician practices. However, some were considered unacceptable (10%) or unsafe (3%), had poor lens quality (9%), had poor frame quality (3%), fitted poorly (43%), and included an incorrect Rx (7%). In particular, those outside the ISO standard should not have been dispensed to the patient and there is clearly room for improvement. Informal written feedback suggested that participants felt rushed in some practices and perhaps had insufficient time for spectacle frame adjustments. In addition, many practices employ non-professionally qualified staff (optical assistants) with relatively little formal training as replacement for, or in addition to, qualified dispensing opticians. These limitations are likely driven by the fact that in the UK (outside Scotland), optometry/optician practices use spectacle dispensing to subsidize the inadequate NHS sight test remuneration, which at ~$32 is well below the cost of the eye examination.[21] A radical change to the funding of eye examinations within the NHS seems to be required so that the eye examination is not a "loss leader"[21] with all its subsequent implications. Several participants (21%) indicated they would purchase their next pair of spectacles online partly due to the absence of purchasing pressure and lack of clarity in pricing. These issues have previously been identified as reasons why both young and older adults avoid attending optometry/optician practices for eye examinations in the UK,[22,23] which again suggests that a change of approach to the funding of eye examinations would be beneficial.

Informal feedback from those participants who preferred the online purchasing system was that it was significantly cheaper (median cost $96 vs. $165), much easier in terms of time and convenience, had a simpler and clearer pricing structure, and had a purchasing system that did not make them feel pressured. However, the service provided by online retailers varied significantly, and it could be improved by providing patients some frames to try on at home as one website currently does, ensuring their stock matches the website information, ensuring more accurate PD and fitting heights (for example, even using an estimated PD of 65 mm for males and 62 mm for females would improve accuracy rather than using a standard 63 mm for all[24]), and by offering a fitting service. PALs (even when properly fitted) are a risk factor for accidents and falls in older people[5–7] due to blur in the lower visual field and distortion in the periphery of the lenses. Therefore, the dispensing of PALs online using estimations of fitting heights and PDs (or patient-measured PDs) that can increase this blur and distortion seems wholly inappropriate. At the very least, websites allowing ill-informed PDs and fitting heights should provide a warning about the dangers (in terms of potential falls) of purchasing these spectacles online. In addition, as indicated earlier, optometry/optician practices could ensure that all PALs are dispensed by qualified dispensing opticians and/or that their optical assistants are provided with significant additional training in this area.

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All authors declare no financial competing interests. It could be argued that as AA, AG, DW, and DE are academic staff for an optometry undergraduate program and that they have a bias in favor of optometry practice (staffed by optometrists in addition to dispensing opticians, optical assistants, and reception staff) rather than online retailers.

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APPENDIX

The two questionnaires given to participants in the study are available at http://links.lww.com/OPX/A256.

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