Article

Physiological Effects of Low-Plus Lenses: Manual Muscle Testing and Nearpoint Lens Prescription

Robin S. Price, BA, OD
W.C. Maples, OD, MS, FAAO, FACBO, FCOVD

Northeastern State University-Oklahoma College of Optometry

Abstract

Background: Nearpoint vision dysfunction and the prescribing of lenses to treat such disorders have long been part of optometry. Various subjective and objective techniques have been developed to determine the optimal lens prescription. Applied kinesiology procedures (manual muscle testing) have been proposed by some practitioners as another aid in determining the appropriate lens power. The purpose of this study was to investigate if manual muscle testing results are affected by the use of low-power plus lenses for near work.

Methods: Fifty-seven fifth grade students were randomized into control and experimental subject groups. Manual muscle testing of the deltoid muscle group was performed by a trained physical therapist as subjects stood with the eyes relaxed looking at distance, then again while reading with their habitual correction, and finally while reading with a series of five low-power lenses over the habitual prescription. The experimental group was tested binocularly with low-plus lenses ranging from +0.25 D to +1.25 diopters (D). The control group was tested binocularly with five sets of plano lenses. The muscle tester did not know what lens was used or in which group each subject was assigned. The muscle test results were then compared to Nott dynamic retinoscopy values.

Results: Muscle strength while reading with the habitual correction was significantly lower than baseline strength while looking at distance with the eyes relaxed. The application of certain low-plus lenses while reading resulted in a significant increase in strength (movement toward relaxation) of the experimental group compared to reading with the habitual prescription alone, while mean strength of the control group was not significantly different. Twenty out of 33 subjects showed a favorable muscle test response to low-plus lens use. Of the subjects who had a positive response to the plus lenses, Nott retinoscopy values were within 0.25 D of the best lens as determined by muscle testing for 70% of the subjects.

Conclusion: The data indicate that the demands of reading result in physiological stress and decreased strength by manual muscle testing techniques. Appropriate low-plus lenses may reduce nearpoint stress. Although manual muscle testing may not yield definitive results for every individual, these techniques may be used to complement standard diagnostic procedures for determining optimal nearpoint lens prescription.

Key Words

low-plus lenses, manual muscle testing, applied kinesiology.

Introduction

Optometry has long been concerned with the management of nearpoint vision dysfunction. Considerable research has been devoted to the development of methods of diagnosing and treating such disorders.[1-6] One of the most common treatment options

Correspondence regarding this article can be e-mailed to maples@nusok.edu or sent to WC Maples, OD 1001 Grand Avenue Northeastern State University-Oklahoma College of Optometry, Tahlequah, OK 74464. All statements are the authors' personal opinion and may not reflect the opinions of any particular institution or organization.

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for nearpoint visual dysfunction is the application of low-power plus lenses.[2,4,7,8]

The rationale for using low-plus lenses to treat nearpoint vision disorders is based on the view that the demands of sustained near work cause stress on the visual system. Skeffington[9-11] held that the visual system is biologically unsuited for the sustained near-vision demands imposed by our culture. He believed that the demands for sustained concentration and mental effort during near work provoke a stress response characterized by a tendency for convergence to localize closer than accommodation. The resultant mismatch between convergence and accommodation leads to symptoms of blurred or double vision.

Birnbaum[1-3] suggests that this phenomenon arises from the activation of autonomic reflexes related to general stress, mental effort, and information processing. These autonomic reflexes involve sympathetic nervous system activation to prepare the body to respond to stress. Sympathetic activation inhibits accommodation, exerting a cycloplegic-like effect. Excess accommodative effort must then be exerted to achieve required accommodation, which generates a tendency toward over convergence and a mismatch between the plane of focus and the plane of convergence.

A small amount of accommodative error (0.50 to 0.75 D) can be tolerated without producing the perception of blur.[12-14] This slight mismatch serves as feedback into the visual system to constantly stimulate vergence and accommodation. A larger lag of accommodation, however, may cause asthenopia and interfere with visual efficiency.[2,15-18] If the state is prolonged, adverse adaptations such as myopia, high exophoria, accommodative insufficiency, and convergence insufficiency may then occur.[2,16] Appropriate low-power plus lenses for near work can serve to balance accommodation and convergence, preserving visual efficiency and eliminating the need for adverse adaptations to nearpoint stress.[2,10,11]

Harmon demonstrated that individuals involved in near-work activities frequently exhibit signs of stress such as increased muscular tension, heart rate, and respiration.[19] He reported that subjects using proper nearpoint lenses showed reduced physiological stress. Differences in lens power as little as 0.12 D were sufficient to induce changes in electrocardiogram monitors, galvanic skin response, skin temperature, respiration, and body posture. Pierce also found favorable physiological effects of low-plus lenses.[20] Research studies indicate that the use of nearpoint lenses can lead to improvement in a child's near working distance,[21-23] improvement in eye movement patterns and oculomotor control while reading,[24] better performance at nearpoint reading and writing tasks,[25] more rapid development of visual perceptual skills,[26] and even the slowing of myopia progression.[27-29] Conversely, inappropriately prescribed low-plus lenses may increase physiological stress.[21,22,31,32] For some subjects, the precise lens power to produce optimal results was critical and specific. Even slight variation from this optimal nearpoint power resulted in significant decreases in comfort and performance. Press concluded that there is no single clinical measure that can predict the appropriate power.[33]

Because low-power plus lenses have been shown to affect physiological activation, some practitioners propose the use of applied kinesiology as an adjunct in determining nearpoint lens prescription.[34] These techniques are designed to evaluate changes in physiological stress during near work, therefore allowing the clinician to determine the lens which minimizes nearpoint stress.

Applied kinesiology (AK) is a form of diagnosis using manual muscle testing as a primary feedback mechanism to identify changes in neurological function of the body.[35, 36] Manual muscle testing (MMT) requires the subject to resist a force applied against the action of a muscle or group of muscles. When performing manual muscle testing, a particular muscle or muscle group is first isolated, and then an external force is applied to take the muscle from an isometric to an eccentric contraction. The examiner feels for quantitative and qualitative changes in the force applied to overcome the resistance of the subject. The muscle test is subsequently said to be "weak" or "strong" based upon the muscle's ability to resist an external applied force over time.

A muscle that tests "strong" is considered to be neurologically excited.[36] In this case, the alpha-motor neurons to the muscle receive a majority of depolarizing excitatory postsynaptic potentials (EPSPs). The nerve impulses have a sufficient frequency to be able to contract the muscle according to the increased pressure during the manual muscle test. A muscle that tests "weak" is considered to be neurologically inhibited.[36] In other words, the balance between excitatory inputs and inhibitory inputs of the central integrative state shifts towards a majority of hyperpolarizing inhibitory postsynaptic potentials (IPSPs).

The purpose of this study was to investigate the hypothesis that manual muscle testing could be used to predict optimal lens power. Namely, does the use of low-power plus lenses as indicated by dynamic retinoscopy positively impact manual muscle test results?

Methods

Eighty-seven 5th grade students were recruited for the study. After obtaining approval from the superintendent, school board, principals and teachers, informed consent forms and assent forms were distributed to parents and students. Fifty-seven students volunteered to participate. To qualify for the study, subjects were required to demonstrate a distance visual acuity of 20/25 or better with their habitual correction and a distance visual acuity of 20/70 or less with a +2.00 D lens before each eye. Subjects were also required to demonstrate gross stereopsis of 100 arc seconds or better with the Wirt Circle stereoacuity test.

Table 1. Key to manual muscle test grading[39]

Test Performance	Percent	Description	Numerals
Ability to hold the test position against gravity and maximum pressure.	100 95	Normal Normal -	5 5 -
Same as above except holding against moderate pressure.	90 80	Good + Good	4 + 4
Same as above except holding against minimum pressure.	70 60	Good - Fair +	4 - 3 +
Ability to hold the test position against gravity	50	Fair	3
Gradual release from test position against gravity	40	Fair -	3 -
Ability to move the limb through partial arc of motion with gravity lessened. Moderate arc, 30%; small arc, 20%.	30 20	Poor + Poor	2 + 2
No visible movement of the limb, although a feeble contraction may be felt.	10 5	Poor - Trace	2 - 1
No contraction felt in the muscle.	0	Zero	0

Subjects were randomly assigned to control and experimental groups, with approximately 2/3 of the subjects in the experimental group and 1/3 of the subjects in the control group. Eleven subjects failed the screening portion of the experiment and were eliminated from the study. Thirty-three subjects remained in the experimental group, and thirteen subjects remained in the control group.

Baseline measurements of near point of convergence (NPC), near point of accommodation (NPA), and near phoria were recorded. The 20/30 reduced Snellen letters were used as the targets for NPC and NPA. Near phoria was determined by cover test at 40 cm, and also measured with the Howell card (modified Thorington technique) at 33 cm. Each subject's lag of accommodation was determined by Nott retinoscopy, in which the patient fixates on a target at 40 cm. The examiner performs retinoscopy at a distance greater than the fixation distance and moves toward the patient until neutrality is observed. The dioptric equivalent of the linear distance between the target and neutrality is recorded and represents the lag of accommodation.

An independent physical therapist trained in manual assessment of muscle strength performed the muscle testing. To isolate the deltoid muscle group, subjects were instructed to stand with feet shoulder width apart and extend their dominant arm to a 90º angle, perpendicular to the front of the body, keeping the elbow straight. The subject was then instructed to resist motion as the physical therapist applied downward pressure on the subject's forearm near the wrist. The subjects held their arm to the side for a total of approximately two to three seconds during the procedure, and were given a one-minute rest between each test. Arm strength was assessed on a grading scale of 0 to 100 (Table 1).

Baseline measurements of arm strength were first recorded with the subject standing in a relaxed posture looking at distance and then again while reading aloud from standard 4th grade level Gray Oral Reading Paragraphs.

Auxiliary lens powers were then randomly selected for testing. Five different lens powers were used binocularly. The experimental group lens powers ranged from +0.25 D to +1.25 D in 0.25 D steps. The control group used five sets of plano lenses. The lenses were all CR-39 plastic and were mounted in identical metal frames at an interpupillary distance of 56 mm to accommodate the average 10-11 year old.[40] For subjects currently wearing glasses for distance correction, the trial lenses were placed over the habitual correction using Jannelli clips (Franel Optical Supply, Maitland, Florida).

The order of introducing each lens condition was randomized across subjects. The first subject in the experimental group was tested in the sequence of +1.00, +0.75, +0.50, +0.25 and +1.25 D lenses. The second subject was tested with +0.75, +0.50, +0.25, +1.25, and +1.00 D lenses. The third subject started with +0.50 D as the first lens of the series, the fourth subject began with +0.25 D, and the fifth subject with +1.25 D. This pattern was continued throughout the experimental testing. Subjects in the control group were given plano lenses each time for a series of five plano lenses.

During the rest period between each lens trial, NPC and near phoria were measured with each set of trial lenses in place.

Results

Analysis of the results using the student t-test showed no statistically significant differences between the control and experimental groups when comparing visual acuity (P = 0.42), stereopsis (P = 0.46), near point of convergence (P = 0.64), baseline near phoria (P = 0.54),

or lag of accommodation (P = 0.54). Baseline measurements of arm strength while relaxed and while reading without the auxiliary lenses also showed no difference between the two groups (P = 0.96, P = 0.95, respectively).

Analysis of muscle testing results revealed a significant difference between strength while looking at distance with eyes relaxed and strength while reading. As shown in Figure 1, the mean arm strength while relaxed was 91% and dropped to 77% when reading (P < 0.001).

Analyses of variance (ANOVA) of arm strength results for the experimental group as a whole showed no statistically significant difference among mean baseline strength while reading and mean strength with any of the trial lenses in place. Results for the control group as a whole were similar, with no statistically significant difference between any of the tests while reading with plano lenses.

Analysis of individual results, however, did reveal significant differences. The best muscle test result was compared to baseline strength measurements for each individual. Analysis of these data for the experimental group revealed a statistically significant difference between baseline strength while reading with no auxiliary lens and while reading with lens that gave the best result from MMT (Figure 1). Mean arm strength increased from 77% to 84% (P < 0.002). There was also some variation in the control group, but there was no significant difference between baseline strength and best result while reading with the plano lenses. The mean results were 77% and 80%, respectively (P = 0.44).

Comparison of the lowest MMT result to baseline strength while reading also revealed a significant difference for the experimental group. Mean strength decreased from 77% to 71% (P = 0.005) in the experimental group. The difference for the control group was similar–the mean decreased from 77% to 72%, but the difference in the control group was not statistically significant (P = 0.169).

Sixty-one percent of subjects in the experimental group (20 out of 33) showed a favorable response to plus lenses as assessed by manual muscle testing. For these subjects, one or more of the low-plus lenses were found to result in increased strength compared to baseline strength while reading without the lenses.

The MMT results were then compared to Nott retinoscopy values. For the subjects who showed a favorable response to low-plus lenses, the correlation between the lens that produced the best result with MMT and the lens predicted by Nott retinoscopy was significant but relatively low (R = 0.50, P = 0.02), (Figure 2). However, the best lens as determined by manual muscle testing was equal to the Nott value for 50% of

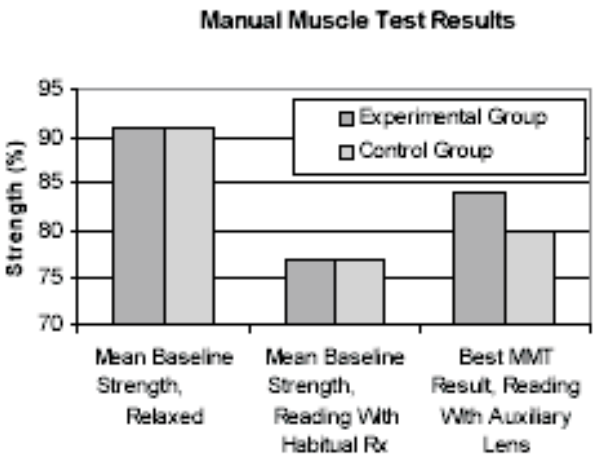

Figure 1. Results of manual muscle testing (MMT) comparing baseline strength while relaxed looking at distance, while reading with the habitual Rx, and while reading with the lens giving the best strength result by muscle testing.

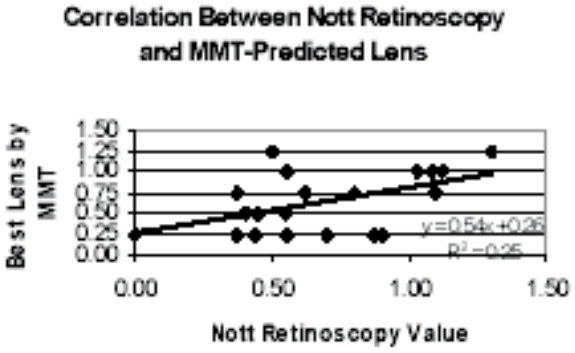

Figure 2. Correlation between Nott retinoscopy and optimal lens found by manual muscle testing for the 20 subjects showing a favorable response to plus lenses by MMT.

subjects, and within ±0.25 D of the Nott lens for 70% of subjects. The best lens from MMT tended to be slightly lower than the Nott value, especially for subjects with higher lags of accommodation (Figure 3).

Discussion

The results of the baseline manual muscle tests (looking at distance with eyes relaxed and then reading with the habitual prescription) support earlier research studies which indicate that near work causes a stress reaction by the body. Muscle strength decreased from 91% while relaxed to 77% when reading.

The data also indicate that the use of appropriate low-plus lenses for near work can reduce physiological stress as measured by MMT. Comparison of muscle strength while reading with the habitual correction to strength while reading with the lens which gave the highest MMT result showed a statistically significant

increase from 77% to 84%. (Figure 2). The control (plano) lens group showed no significant variation.

This research also supports the view that there is not one universal optimum lens power for all persons in this age range. When any of the specific lens powers in this project were analyzed as a group, no single dioptric value was the best lens for all subjects. In a majority of these subjects, Nott retinoscopy identified the optimum lens, according to MMT results, within 0.25D.

The data also suggest that non-optimal lenses may be detrimental. The lens which resulted in lowest strength on muscle testing was significantly lower than baseline strength while reading with the habitual distance correction, a decrease from 77% to 70%. The control group again showed no significant variation.

The study was limited by several factors. The physical therapist who performed the muscle testing was not allowed to compare lens values relative to one another on each subject. The muscle tests were performed one minute apart, and other subjects were tested during this rest period. The examiner graded arm strength based only on the muscle test grading criteria (Table 1) and not relative to the other lenses on each individual. Had we designed the experiment so that all five lenses could be evaluated relative to one another on a particular individual consecutively, muscle testing may have been more definitive in predicting a "best" lens for a greater number of subjects.

Another limitation was that only five plus lens powers were used during testing. Minus lenses have also been shown to be beneficial in some instances.[6] Some practitioners also believe that many individuals are sensitive to 0.12 D steps, and that for certain individuals, a +0.37 D lens may be better than +0.25 D or +0.50, for example.[34] Higher lens powers may also have proved beneficial.

Other dynamic retinoscopy techniques and phorometric procedures such as binocular cross-cylinder testing may correlate differently with muscle test results. The subjects were all fifth graders. Other age groups may respond differently to manual muscle testing.

Conclusion

The results of this experiment indicate, as Skeffington and others have hypothesized, that the demands of reading increase physiological stress. The data also show that the use of appropriate low-power plus lenses for near work may decrease stress, while placebo lenses have no effect.

The optometrist may utilize MMT as a probe test to help determine if plus lenses are beneficial for a patient or to help decide between different lens powers. Applied kinesiology procedures are not intended to be used as a single method of diagnosis. These techniques may be used to complement standard diagnostic procedures for determining optimal nearpoint lens prescription.

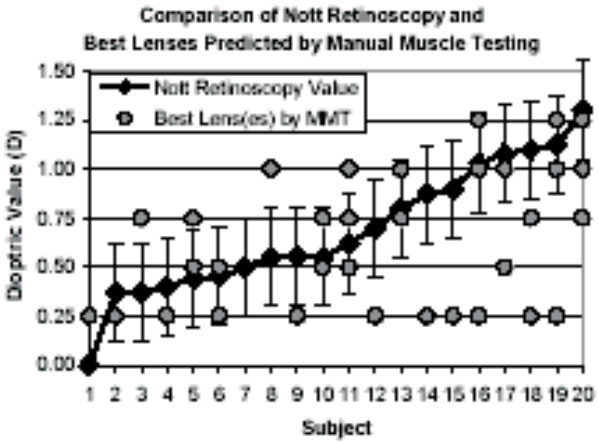

Figure 3. Comparison of Nott retinoscopy to best lens(es) found by manual muscle testing (MMT). For subjects in which more than one lens tested equally strong, all "best" lens powers are included. Error bars represent ±0.25 D from the Nott value.

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