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Reliability of a computer-based system for measuring visual performance skills

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Abstract

BACKGROUND: Athletes have demonstrated better visual abilities than nonathletes. A vision assessment for an athlete should include methods to evaluate the quality of visual performance skills in the most appropriate, accurate, and repeatable manner. This study determines the reliability of the visual performance measures assessed with a computer-based system, known as the Nike Sensory Station.

METHODS: One hundred twenty-five subjects (56 men, 69 women), age 18 to 30, completed Phase I of the study. Subjects attended 2 sessions, separated by at least 1 week, in which identical protocols were followed. Subjects completed the following assessments: Visual Clarity, Contrast Sensitivity, Depth Perception, Near–Far Quickness, Target Capture, Perception Span, Eye–Hand Coordination, Go/No Go, and Reaction Time. An additional 36 subjects (20 men, 16 women), age 22 to 35, completed Phase II of the study involving modifications to the equipment, instructions, and protocols from Phase I.

RESULTS: Results show no significant change in performance over time on assessments of Visual Clarity, Contrast Sensitivity, Depth Perception, Target Capture, Perception Span, and Reaction Time. Performance did improve over time for Near-Far Quickness, Eye-Hand Coordination, and Go/No Go.

CONCLUSIONS: The results of this study show that many of the Nike Sensory Station assessments show repeatability and no learning effect over time. The measures that did improve across sessions show an expected learning effect caused by the motor response characteristics being measured.

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Researchers and clinicians have sought to discover the specific vision skills that correlate to success in sports. The vision and visual perceptual skills identified as important include static and dynamic visual acuities, contrast sensitivity, distance stereopsis, accommodative-vergence facility, span of perception, central eye-hand reaction and response speeds, and peripheral eye-hand response speed.[1,2] Two extensive review articles cite numerous studies to conclude that athletes have demonstrated better visual abilities than nonathletes, and that top athletes—those who are most successful—often have visual abilities that are superior to lower-level or less successful athletes.[3,4] Some aspects of these skills commonly are assessed as part of a routine vision examination, but many are not evaluated for various reasons. For some vision skills, there is little or no standardization of assessment techniques, and some instrumentation may be outdated, if available at all.

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To provide specialized vision care to an athlete, the eye care practitioner should identify the vision factors essential to successful performance of the sport tasks. The vision assessment should then include methods to evaluate the quality of those skills in the most appropriate, accurate, and repeatable manner. A significant body of research compares performance on various measures of visual function in athlete populations to guide the clinician in selecting appropriate visual measures, as described below. The battery of tests comprising the Nike Sensory Station (Nike, Inc., Beaverton, Oregon) attempts to address this clinical need.

Static visual acuity

Assessment of visual performance skills routinely begins with measurement of static visual acuity (SVA). Compromised SVA can negatively affect other areas of visual performance.[1] Previous research has found mixed results regarding SVA in athlete populations: when SVA is assessed using chart systems with 20/20 as the best acuity measureable, there is no statistically significant difference in the visual ability of athletes compared with that of nonathletes.[5,6] Even when a best acuity demand of 20/15 is presented, Laby et al.[7] found that 81% of professional baseball players could achieve that level. Laby et al.[7] subsequently modified their assessment method to achieve acuity demands down to 20/7.5, reporting overall mean SVAs of approximately 20/13 with several athletes attaining SVAs of 20/9.2 or better.

However, several studies in which visual acuity was degraded with plus addition lenses did not find a detrimental effect of defocus.[8-10] Review of the study protocols reveals that subjects were assessed on predictable, repetitive motor tasks. One of the goals of the current study is to determine which assessment tasks, if any, are subject to a simple motor learning effect with repeated measurement.

Dynamic visual acuity

Dynamic visual acuity (DVA) generally is defined as the ability of the visual system to resolve detail when there is relative movement between the target and the observer.[1,4,11] Many sports involve extensive movement of an object (e.g., ball, puck), competitors, teammates, the athlete, or all simultaneously. Often at elite levels of sport, the velocity of movement between the athlete and the target is tremendously high; therefore, it is essential for athletes to be able to accurately perceive and identify critical target features during dynamic situations. Stine et al.,[3] in a review of the literature, found that athletes show superior DVA abilities compared with nonathletes and that elite athletes have better DVA than do amateur or nonelite athletes. These findings suggest that there is an important link between elite athletes and DVA ability. On the other hand, Ward and Williams[12] reported no significant differences in performance on a DVA test between elite and subelite youth soccer players. However, their use of a predictable rotator device to measure this function may not have been environmentally appropriate to simulate the visual task demands of a large-field, dynamic sport, such as soccer. Although many researchers agree about the importance of DVA in sport,[4] this visual skill is often not assessed in clinical practice because of limitations in commercial instruments available to measure it.

DVA decreases with increasing target velocity.[11] To have a high DVA requires the ability to resolve targets at a higher velocity than average. Brown[13] concluded that the relationship between DVA and target angular velocity is approximately linear for targets moving at velocities up to 90° per second. DVA is affected by both the target parameters (e.g., target luminance, target/observer velocity, and exposure time of target) and the physiologic abilities of the observer (e.g., resolving power of the eye, oculomotor abilities, peripheral awareness, and psychological abilities to interpret what is seen).[14] Enhancement of either the target parameters or physiologic abilities of the subject can improve DVA abilities.[14-16]

Contrast sensitivity

Contrast sensitivity measures the visual system's ability to process spatial or temporal information about objects and their backgrounds under varying lighting conditions.[17] Measuring an athlete's contrast sensitivity is important because most sports involve interpreting visual information at contrast levels below what is measured with a typical visual acuity chart.[1] Performance of athletes on contrast sensitivity testing is significantly better than that of nonathletes across all spatial frequencies evaluated.[1,18,19]

Ginsburg[20] showed that contrast sensitivity decreases as the velocity of a target increases and that, as target size decreases, contrast sensitivity demand increases. Ginsburg[20] also showed that higher spatial frequencies will be affected before lower spatial frequencies by changes in target distance, movement direction, and low illumination. Contrast sensitivity also may be degraded in contact lens wearers if lens fit or water content are not optimal for the patient, resulting in corneal edema even when SVA seems acceptable.[21] Finally, contrast sensitivity can increase or decrease after refractive surgery.[22]

Many commercial systems are available to measure contrast sensitivity.[23] Several use linear grating patterns that vary in spatial frequency, contrast level, and, possibly, orientation. Others use letters or numbers of varying contrast levels or size. Contrast sensitivity measurements usually involve determination of a threshold contrast level at specific spatial frequencies.

Stereopsis

Determining distance and spatial localization of an object is a necessity for athletes in many sports. These judgments can be made using monocular depth cues, but it is suggested that superior binocular depth perception (stereopsis) can be advantageous for the athlete.[24] The research