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Efficacy of High-Performance Vision Training on Improving the Reaction Time of Collegiate Softball Athletes: A Randomized Trial

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Purpose: A well-developed visual system is integral to the dynamic nature of sport performance among collegiate athletes. Occupational therapists play an important role in addressing an athlete's visual skills through incorporating meaningful occupation, in this case sport, into interventions while addressing specific client factors. The aim of the study was to examine the efficacy of occupational therapist led high-performance visual training in improving the reaction time of collegiate softball athletes. **Methods:**A mixed method approach was used to collect both qualitative and quantitative data. Qualitative data were collected to assess athlete perceptions of sport, and quantitative data were collected using a mixed within group and between group design. Twenty-one participants were randomly allocated into two groups, each receiving a 6-week intervention which followed an evidence-based protocol. Group A consisted of Dynavision™ D2 training, and Group B of non-machine, therapist-led, visual training, twice weekly for 10-15 minutes each. **Results:** Results of the study highlight perceived meaningfulness of sport and display that both theory-based protocols were effective, as Group A and Group B experienced significant decreases in reaction time. However, decreases in reaction time were more significant for Group A in both proactive and reactive Dynavision™ D2 training modes. **Conclusion:** Results suggest that both the Dynavision™ D2 and alternative vision training as led by occupational therapists may be beneficial in improving the proactive and reactive reaction times of collegiate athletes, enhancing their abilities to participate in meaningful sports, but the Dynavision™ D2 may be a more effective training tool, especially related to proactive reaction time training. **Keywords:** Dynavision™ D2, sports performance, vision training, softball, athletes, occupational therapy, reaction time

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INTRODUCTION

According to the National Collegiate Athletic Association (NCAA), more than 460,000 student-athletes participate in collegiate sports annually; of this, 19,489 are NCAA collegiate, softball athletes.[1,2] Performing at an elite level requires dedication, training, and motivation. Theoretical principles, when applied to athletes, postulate that athletes possess an innate desire to master the sport in which they participate;[3] they seek ways to enhance their sport performance to achieve a sense of mastery. Success in sports requires visual engagement in one's environment,[4] as more than 80% of input during sport participation is visual in nature.[5] An athlete gathers information from the environment, which is sent to the brain where it is interpreted and processed. Appropriate action in response to this input is determined in a fraction of a second. Therefore, speed in processing visual input is vital to an athlete's performance during sport, which can lead to enhanced success and reduction in injury.[5, 6]

Despite vision playing a large role in the sport performance of collegiate athletes, many athletes do not receive specialized training to advance such skills, nor is there consistency in who provides such training.[7] Most often visual performance training is carried out by athletic trainers and optometrists.[7,8] Occupational therapists, however, afford a unique skill set including knowledge of the visual system, neurology, sensory processing, and task analysis, which can provide valuable insight to the training of athletes. Occupational therapists possess the knowledge and ability to assist in training the visual system, as they are educated to examine and enhance the visual skills to improve occupational performance.[9] For athletes, sport performance is a meaningful occupation to which they dedicate much time and effort. Often, athletes are motivated to improve performance within this occupation, which is evidenced in their commitment of an average of 32 hours per week to athletics.[1]

BACKGROUND

Visual Training

Different methods of visual training have been investigated, with the best method yet to be determined. A study completed by Zwierko and colleagues[10] examined the benefit of a traditional vision-training program consisting of smooth pursuits, saccades, accommodation, convergence, divergence, and other visual exercises in improving athletes' abilities to effectively use the visual system to meet the demands of the sport (see table 1 for definitions of terms). Results from the study determined that athletes' binocular functions increased following completion of the program.[10] Similar studies investigating the effectiveness of traditional vision training programs in increasing visual and sport performance of young adults did not find significant impacts on the visual system nor the sport performance of athletes.[11,12] Therefore, the efficacy of traditional vision training programs for improving aspects related to sport performance, such as reaction time of athletes, is inconsistent and lacking.

Accommodation	• Ability to change focus from near to far and vice versa[13]
Confrontation	• Gross measurement of visual fields[13]
Convergence	• Alignment and coordination of both eyes together to fixate and focus on objects moving near[13]
Divergence	• Alignment and coordination of both eyes together to fixate and focus on objects moving away[13]
Dynamic visual acuity	• Detail vision/resolution during head movement[13]
Eye dominance	• Preference of visual input from one eye over the other[13]
Saccades	• Rapid eye movements to maintain focus[13]
Smooth pursuits	• Visual scanning; slow movements that keep an image steady and in focus[13]
Static visual acuity	• Detail vision/resolution with head stationary[13]

Table 1. Vision Terminology

Dynavision ™ D2

An alternative vision-training tool is the Dynavision™ D2. The Dynavision™ D2 is a light-training device used to assess and improve an individual's reaction to central and peripheral stimuli, as well as strengthen sensory motor integration.[14] The Dynavision™ D2 is commonly used in upper-level sports training in preparation for elite competition.[15] Research confirms that the Dynavision™ D2 may be used to increase the demands of training for various sports, including softball.[6,16]

The Dynavision™ D2 is an effective tool for enhancing the eye-hand coordination and visual performance of ball-sports similar to softball. Clark and colleagues[16] determined that Dynavision™ D2 training significantly increased the visual abilities and eye-hand coordination of Division I baseball athletes. An additional study determined that Dynavision™ D2 training enhanced the perceptual skills of young hockey players, improving their visual and motor reactions times.[6] Studies have also revealed that the Dynavision™ D2 is a reliable method for testing the reaction times of collegiate athletes.[14,17,18] However, no studies have explored the efficacy of use of the Dynavision™ D2 with softball athletes. Also, no studies have explored using this device as an occupational therapy intervention in order to translate theoretical evidence into practice to enhance visual and cognitive processing and organization, with the ultimate goal of incorporating visual training that will transfer to improvements in on-field sport performance.[19] Therefore, the purpose of this study was twofold: 1) to explore the effectiveness of occupational therapy informed visual training for athletes (utilizing Dynavision™ D2 and non-machine approaches), and 2) to determine the efficacy of the Dynavision™ D2 in comparison to traditional visual training in improving the reaction time of collegiate softball athletes.

METHODS

Research Design

This study was completed using mixed methods of a qualitative survey along with experimental-type research with a two-arm, randomized controlled trial, mixed within-group and between group design. Participants (N=21) were randomly allocated into two intervention groups (Group A and Group B), using a randomized computer generator. Each group utilized structured, theory-driven protocols (outlined below) established by experienced occupational therapists. Group A (n=10) participated in Dynavision™ D2 vision training, and Group B (n=11) participated in vision training exercises emphasizing similar skills: Reaction time, visual scanning, central-peripheral integration, visual-motor coordination, visual accommodation, and visual attention. Participants and research investigators were not blind to group allocation. Data were gathered following intervention, incorporating these components for outcomes of reaction time.

Research Participants

Participants were recruited from a Division I Women's Softball team in the Midwestern United States. Participants were included if they were between the ages of 18-22 years and were collegiate softball players from the University. Twenty-two participants were recruited, met inclusion criteria, and were randomly allocated to one of two intervention groups (see Figure 1). Participants were recruited by means of convenience sampling through contact with the team's coach. Data were collected at the team's training facility. During the study, one participant withdrew from the softball team, and her data were not included in analysis. Participants were each assigned a random number, and all data collected during testing and intervention were de-identified, reducing the risk of preconceived biases during analysis. Athletes were in non-tournament, fall season during all testing points and intervention, which reduced confounding variables.

Research Instruments

Survey

A survey was developed by researchers in order to explore athletes' perceptions of sport as a meaningful occupation. Review of literature regarding motor learning, occupational science, and perceptions of meaningfulness informed survey development. In order to increase the validity of the survey, all research members reviewed questions separately. Additional graduate-level students reviewed the survey prior to dissemination. Information gathered from reviewer feedback was compiled, and survey questions were revised. The final survey included demographics such as age, current rank in undergraduate study (freshman, sophomore, junior, or senior), and years spent in sport. Additional open-ended questions regarded vision history, roles as a student-athlete, time spent in sport, and meaningfulness of sport. The survey also included questions using a Likert-type scale, asking the athletes to rate from 1-10, with 10 being the most, regarding importance and meaningfulness of sport and motivation to improve skill related to sport.

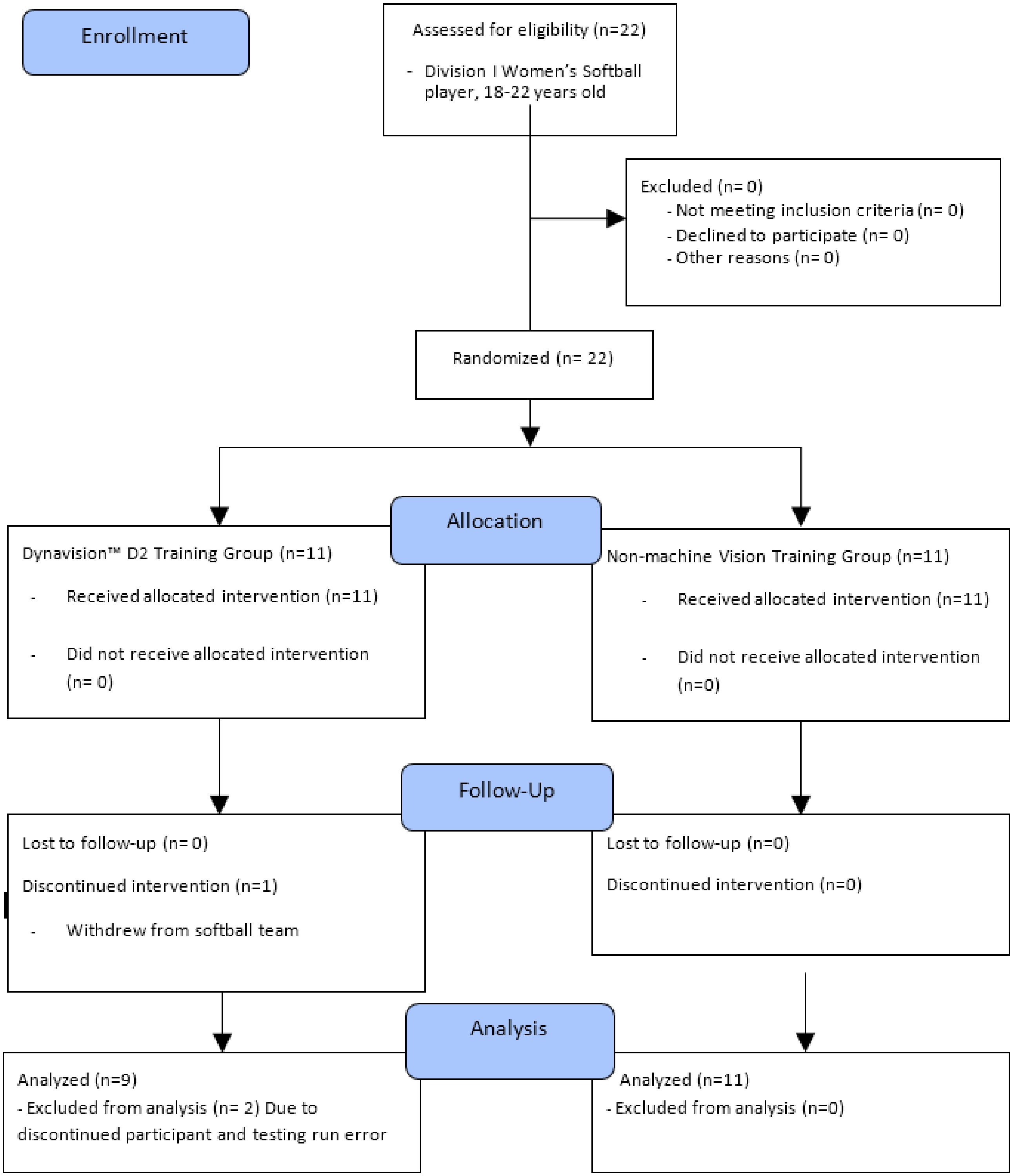

Figure 1. Consort Flow Diagram

Ten-point Likert scales provide respondents more options and improve sensitivity and accuracy, especially when positive responses are anticipated, as was the case with student athletes rating meaningfulness of sport and motivation to improve in sport.[20] See table 2 for a list of questions from the survey.

Demographics	• Name • Age • School Rank (Freshman, Sophomore, Junior, Senior)
Eye History	• Have you ever had your vision tested? If so, what were the results? • Do you wear contacts or glasses? Do you wear these while playing softball? • Have you ever had any injuries to your eye(s)?
Softball	• What does softball mean to you? • What do you enjoy most about softball? • How many years have you played softball? • How much time per week (in hours) do you spend on softball activities? • On a scale of 1-10 (10 being the most), how important is softball to you? • On a scale of 1-10 (10 being the most), how motivated are you to improve your softball skills?

Table 2. Qualitative Survey Questions

Dynavision™ D2

Four training and testing modes on the Dynavision™ D2 were used to gather data related to visual and motor reaction times. Modes A and D were specifically used during testing, and Modes A, B and C were utilized during intervention sessions. Mode A is a proactive mode in which red lights illuminate and remain lit until hit by the athlete. Once a light is hit, another light illuminates in a different, random location; this pattern continues for the run time of the mode. The information collected during Mode A determined individual reaction times both in testing and intervention. These proactive reaction times were used to set a reactive time for Mode B (per pre-established protocol guidelines[21]), which was used to challenge the athletes to improve reaction time, peripheral awareness, and visual scanning during intervention. In reactive Mode B, one light illuminates for a preset amount of time before moving to a different, random location. Unlike Mode A, lights in this reactive mode move even if un-hit. This mode added increased demand, providing an appropriate challenge for athletes (since set according to individual reaction times), promoting skill development and improvement.

Mode C is a scanning mode that was used during intervention to strengthen visual field awareness, visual pursuits, visual scanning, and visual attention. During this mode, red lights appear in the outermost ring and travel in clockwise and counterclockwise movement patterns. Athletes are positioned approximately six feet from the board and are instructed to track the lights with their eyes, without moving their heads. While completing, investigators observed oculomotor and visual tracking skills. Mode D is a reaction time testing mode that was used at the three assessment points to measure visual, physical, and motor reaction times. During this mode, two red lights illuminate (one at a time) in a predetermined area of the board; users are set up at the board where they press and hold one light. Once the second light appears, participants move as quickly as possible to depress the second light, using the same hand. Mode D consists of a set of six tests, each of which were performed five times to determine averaged scores for reaction time. Three of the tests were performed with the right upper extremity, and three with the left.

Vision Testing

Each athlete completed baseline, post-intervention, and follow-up re-assessment of eye dominance, confrontation, oculomotor field of view, smooth pursuits, saccades, convergence, accommodation, and static and dynamic visual acuity. See table 1 for definitions of terminology.

Procedure

A protocol was created by research investigators which was founded in occupational science and motor learning, multisensory integration, and cognitive rehabilitation theories.[21] Each approach was integrated to promote skill development of both groups. All tasks within groups were established on a continuum of simple to complex in order to move skills from conscious to unconscious and increase automaticity.[22,23] Tactile, proprioceptive, and vestibular components were integrated in order to promote higher-level skills such as attention, body/brain specialization, and visual processing.[24] Cognitive and perceptual loads were used to improve neural organization and to enhance processing time and attention for split-second decision making required during game play.[19,25] Among the Dynavision group protocol (Group A), the tachistoscope was utilized**.** This device displays pictures, words, numbers, or symbols and is located in the upper middle of the Dynavision™ D2. This feature allows intensification of complexity during training, through cognitive and visual loading.

Prior to beginning the study, approval from the University's Institutional Review Board (IRB) was obtained. Once approval was granted, the first author sent a recruitment email to athletes via university email. Informed consent was obtained from all athletes who volunteered to participate in the study who met inclusion criteria. Prior to initiation of pre-testing, the survey was disseminated to athletes to understand their roles as student athletes as well as their perceived meaningfulness of participating in sport and their motivation to improve skills.

During the study, each participant's data were recorded and placed within a binder that was kept confidential and locked in a cabinet following each session. To improve the validity and reliability of the study, a manual was produced and followed which outlined the protocol for each of the groups. The manual included verbal directions, descriptions of sessions, and data recording sheets. The research investigators also rehearsed each treatment session prior to conducting with the participants to ensure consistency and inter-investigator reliability.

Data were gathered over a span of 10 weeks. Initial testing was completed the first week, which included vision testing and Dynavision™ D2 pretests. Eye dominance, confrontation, oculomotor range of motion, smooth pursuits, saccades, convergence, accommodation, and static and dynamic visual acuity were tested and recorded. Dynavision™ D2 pre-testing was performed using Modes A and D. Three practice trials were completed with Mode A to familiarize the athlete with the Dynavision™ D2, and a fourth trial was recorded as the pretest baseline. Mode D was performed using each upper extremity for three tests (five trials per test); an overall average reaction time was recorded, which is shown in Table 5. No reaction time data were collected from Modes B or C, as these modes were utilized only during intervention to train reaction time and visual scanning.

During weeks two and three, all participants (Groups A and B) completed a familiarization period using the Dynavision™ D2. This consisted of 10-15 minute sessions, two times per week, using three trials of Modes A and B. Participants began with Mode A. Performance on the third trial was used to set the reactive time for Mode B, subtracting 0.05 seconds from the athlete's proactive time in order to challenge the athletes to react more quickly. This two-week familiarization was intended to reduce user bias of the Dynavision™ D2 training group, Group A.

Following pretesting and two-week familiarization, group-specific intervention sessions began at week four of the study. Each participant received 15 minutes of intervention, two times per week for six weeks, following the established protocol by Feldhacker and Lucas Molitor.[21] Using the theoretical foundation as described above, protocols for the Dynavision™ D2 group and the vision training group were established to address similar skills in order to compare machine and non-machine led intervention. Each week, the Dynavision group completed one session utilizing Modes A, B and C, and the other session utilizing the tachistoscope. See table 3 for protocol-specific interventions related to visual exercises for Group B; Group A followed established protocol by Feldhacker and Lucas Molitor.[21] The protocol was designed to prevent a ceiling effect from occurring, which happens when the independent variable no longer has an impact on the dependent variable. To prevent this effect and to maintain an adequate challenge, the demands of each session increased in complexity to load the athletes' sensory systems to promote learning and neuroplasticity. Sessions for both groups required the use of multiple sensory systems, including tactile, auditory, vestibular, and proprioceptive. By increasing the demands on the central nervous system, the processing, interpretation, and response were gradually improved over time to enhance visual skills and brain and body specialization for elite sport performance.[19, 22-25]

The final week of the study, week ten, consisted of post testing carried out using the same assessments as were completed at study initiation (Modes A and D). At one and two months post intervention, retention testing was completed to assess skill maintenance in the absence of further intervention.

Data Analysis

Pretest, posttest, and follow-up data were analyzed using the Statistical Package for Social Sciences (SPSS) Version 25. A Two Factor Repeated Measures Analysis of Variance (ANOVA) was completed to analyze changes in means as assessed across multiple time points within and between-subject factors to determine if there was a difference in reaction time among and between Dynavision™ D2 and vision training groups. Significance (α) was set at 0.05.

Week	Exercises
Week 1	Saccades, pursuits, and reaction time
Week 2	Accommodation and central peripheral integration
Week 3	Attention and reaction time
Week 4	Saccades, pursuits, and central-peripheral integration
Week 5	Attention and reaction time
Week 6	Accommodation and central peripheral integration

Table 3. 6-week Intervention Protocol for Group B

Prior to completing pre-testing, a survey was administered to assess role of student athletes and sport as a meaningful occupation. Quantitative data from Likert-scale items were analyzed for means and frequencies utilizing ANOVA. Qualitative data included completed written survey responses. Data were initially coded openly using Saldana's methodology.[26] This approach is used for analysis of open-ended data during initial review of the data. Coding was then reviewed a second time and compared among investigators, which were then categorized according to repeated and emerging ideas in order to draw connective themes. Interrater review of thematic data through reflexivity reduced potential bias.

RESULTS

Of the 21 enrolled athletes, 10 athletes were allocated to Group A for Dynavision™ D2 training, and 11 athletes to Group B for traditional, therapist-led, non-machine, vision training. During the study, one participant from Group A withdrew from the softball team, and her data were not included in analysis. Also, data of one participant from Group A were extracted prior statistical analysis. Removal of this erroneous data, due to measurement error with incorrect testing run, allowed for normal distribution of the data. As such, final analysis included Group A (n=9) and Group B (n=11).

Prior to baseline testing, all athletes completed a survey which assessed the occupation of sport. Emergent themes from the qualitative feedback were overall positive and described bonding, enjoyment, friendship, and connecting with others through competitive collaboration as arising from engaging in softball. Athletes ranked importance of softball on average 9.5/10±.91 and motivation to improve their softball skills by engaging in vision training 9.9/10±.46.

Meaningfulness and motivation directly related to the theoretical foundation of the protocol and were important to anticipate engagement and improvements among athletes.[21] See table 4 for survey results. All athletes scored within normal limits for visual testing. At baseline testing, both groups had similar mean pretest scores for Mode A (Group A: M= 0.78±0.06 seconds; Group B: M= 0.81±0.04 seconds) and Mode D (Groups A and B: M= 0.42±0.06 seconds).

Qualitative Emergent Themes of Meaningfulness	Number of Years Played Softball	Importance of Softball (1-10)	Motivation to Improve Softball Skills (1-10)
Enjoy, bond, love, passion, friendship, team, competition	M= 12±2.5 years	M=9.5±0.91	M=9.9±0.46

Table 4. Survey results

Quantitative data were analyzed for assumptions of normality and were found to meet requirements for parametric testing. Prior to completing an ANOVA, data were assessed for sphericity, with findings indicating no violation for Mode A data. Results indicated that participants improved in proactive reaction time, and this change was statistically significant (Λ = 0.14, $F(3, 57)$ = 54.66, p= 0.000; η_p^2= .87 with observed power at 1.00). In completing analysis of Mode D within groups, the assumption of sphericity was violated. Thus, Greenhouse-Geisser correction was used. Results indicated that participants' improvement in reaction time was statistically significant (Λ = 0.34, $F(1.99, 35.86)$ = 17.02, p= 0.001; η_p^2=.66 with observed power at 0.99).

Although both groups demonstrated statistically significant improvements, between group comparison indicated that the decrease in proactive time (Mode A) was significantly greater for those in Group A ($F(1, 19)$ = 10.408, p= 0.004; η_p^2=.354). From pretesting to post testing for proactive Mode A, Group A displayed an 18% decrease in reaction time (M 0.78±0.06 to 0.65±0.05 seconds) while Group B experienced a 10% decrease in reaction time (M 0.81±0.04 to 0.73±0.06 seconds). At a two-month follow-up, Group A displayed an average reaction time of 0.64±0.05 seconds and Group B 0.73±0.06 seconds, exhibiting retention for proactive testing among both groups, with Group A maintaining a statistically significant improvement over Group B. See table 5 for results.

Results for Mode D indicated both groups demonstrated statistically significant improvements, but the difference between groups was not significant ($F(1, 18)$ = .310, p= 0.585; η_p^2=.017). Group A displayed a 14% decrease in reaction time (M 0.42±0.06 to 0.36±0.04 seconds) which was maintained at two-month follow-up, and Group B displayed a 12% decrease in reaction time (M 0.42±0.06 to 0.37±0.04 seconds) which improved at two-month follow-up (M= 0.36±0.05). See table 5 for results.

	Pretest	Posttest	Follow Up 1	Follow Up 2
Group A Mode A	0.78±0.06	0.65*±0.06	0.65*±0.05	0.64*±0.05
Group B Mode A	0.81±0.04	0.73*±0.06	0.72*±0.06	0.73*±0.06
Group A Mode D	0.42±0.06	0.36*±0.04	0.36*±0.03	0.36*±0.05
Group B Mode D	0.42±0.06	0.37*±0.04	0.38*±0.05	0.36*±0.05

Table 5. Average reaction time for Dynavision™ D2 and visual training groups for proactive and reactive modes a four time points: Pretest, Posttest, 1 Month Follow Up, 2 Month Follow Up. *Note: * indicates significance with p ≤ .05*

DISCUSSION

The study sought to investigate the effectiveness of an occupational therapy informed visual training approach as well as to determine the efficacy of the Dynavision™ D2 in comparison to traditional, non-machine vision training on improving the reaction time of collegiate softball athletes. Investigators first sought to gain an occupational perspective of the student athletes through a survey. Survey results indicated student athletes viewed being a part of the softball team as enjoyable, as it connects them with others and allows them to be competitive and successful. Overall, they rated participating in sport as meaningful and were motivated to engage in training to improve skills that would allow them to better participate in this meaningful occupation. This knowledge allowed investigators to utilize a protocol with a theoretical foundation founded upon motivation and meaningful engagement.[21]

Analysis of results indicated that high-performance vision training, as informed by skilled occupational therapists, was effective in improving the reaction time of Division I collegiate softball athletes, as shown by decreased proactive (Mode A) and reactive (Mode D)reaction times. This decrease in reaction time is an indicator of neuroplasticity, improved speed in adaptability, and improved dynamic visual acuity, visual concentration, tracking, eye-hand-body coordination, and central peripheral visual integration, each of which is necessary for superior sport performance on the softball field.[27] Overall, both protocols for Groups A and B (Table 3 above) proved effective in decreasing proactive and reactive reaction times among collegiate softball athletes, with statistically significant improvements within each group. However, the Dynavision™ D2 group demonstrated a large effect (η_p^2= .87) and the visual training group had a medium effect (η_p^2=.66), indicating the Dynavision™ D2 may be slightly more effective. Also, results displayed that Group A experienced a more significant decrease in reaction times than Group B. Those who participated in Dynavision™ D2 training experienced an eight percent larger decrease in reaction time than the vision training group from pretest to posttest and a 0.07 second faster average reaction time at two-month retention for proactive testing. Though this seems like a small improvement, fraction-second timing is critical to success in softball, and this proved to be a statistically significant improvement over those in Group B.[28] Findings suggest both the Dynavision™ D2 and traditional, non-machine visual training methods are effective intervention approaches to enhance the visual skills of an athlete population.

Results of this study are in line with prior research determining that the Dynavision™ D2 is an effective tool for decreasing reaction time, expanding population use to softball athletes.[14,17-18] Additionally, Cross et al. [18] found that 6 weeks of Dynavision™ D2 training successfully improved the visual motor skills of collegiate volleyball players. Six weeks of intervention proved effective in this study as well; therefore, results of the current study are in accordance with previous literature conducted within the topic area. While reaction time was the focus of the outcomes of this study, it is recognized that athletes may have increased visual skills in other areas not captured during D2 testing. Among these skills, central peripheral integration and scanning, for example, were not assessed in isolation but rather in relationship to their role in reaction time. Incorporating additional instruments to assess such skills should be the focus of future studies.

Limitations

The learning effect associated with the Dynavision™ D2 is a limitation of this study and may have contributed to the difference in decreased reaction time for Group A. Minimizing this limitation was attempted by allowing two weeks of familiarization prior to the group-specific intervention; however, use of the Dynavision™ D2 for training and testing is still a limitation. It would have benefitted investigators to re-collect baseline data after familiarization to assess group differences, as only initial pre-test data were collected for comparison to posttest and follow-up data. An alternative tool for testing reaction time would have strengthened this study. Two primary investigators, along with the assistance of five occupational therapy students, engaged in data collection. Due to the number of researchers, implementation of the interventions could have varied slightly; however, this limitation was minimized through use of the protocol manual. Also, the researchers gathered weekly to discuss and practice the upcoming sessions to reduce variability. Lastly, external validity is limited as this study focused on the implementation of vision training with only one collegiate sports team.

Implications

Few research studies have focused on the retention of skills. Future research is needed to validate the results obtained from this study regarding the retention of skills. Skills were retained for two months post intervention, until athletes began their in-season, spring practice. This study took place during athletes' non-tournament, fall season in order to decrease confounding variables. Fall season is considered to be off-season because all games are non-tournament, and typically fewer than 10 games are played, compared to approximately 55 in-season. Ongoing follow-ups were not possible with this study due to in-season status, but it is anticipated that a decline in skills will occur without ongoing intervention; additional research is needed to verify this hypothesis. Data for athletes in Group A were collected at each session, and no plateau was noted, with consistent improvements through post-testing. Continued research is needed to determine the appropriate number of training sessions needed before skills begin to plateau. The assignability into sport-specific performance criteria is the next step that should be taken. Though the protocol was established by experienced occupational therapists who founded it in theoretical and evidence-based principles, which have been shown to transfer visual and cognitive skills, generalization to game-play should be explored. Such research is valuable to show if results from a laboratory can transfer to on-field performance. Lastly, this research study focused on one collegiate sports team; future research can expand the population size to incorporate a variety of athletes. Continued research will help to increase the external validity of the results.

Future Research

The results of this study are in accordance with previous literature conducted within the topic area, but continued research is needed to validate findings. This study tested the effectiveness of high performance vision training up to two months post training; therefore, further research is needed to test longitudinal effects of vision training. The present research study focused on the softball athletes equally, instead of providing position-specific intervention. Future research could investigate the effectiveness of adapting high performance vision training to integrate position-specific skills. Also, this study focused solely on proactive (Mode A) and reactive (Mode D) reaction times; however, athletes may have experienced meaningful improvements in other areas not captured with reaction time. Further assessment of isolated visual skills would be beneficial in informing effective interventions. Lastly, future research should include a control group in the study to rule out other factors as being contributed to the results.

CONCLUSION

The breadth of knowledge regarding the use of the Dynavision™ D2 apparatus for vision training is limited, especially within the occupational therapy literature. Findings from this study indicated that the Dynavision™ D2 device helped to improve the reaction time of Division I collegiate softball athletes when instructed using the skills and knowledge of an occupational therapist. Moreover, the improved reaction times were retained at both the one and two months following intervention. Results of this study highlight the Dynavision™ D2 as an effective tool for decreasing reaction time and for maintaining this reduction. These findings expand upon previous research and validate the need for continued research to strengthen study conclusions. Innovative to this study is the emphasis on neurological, cognitive, sensory, and motor learning theories as a premise for intervention. Obtaining a sufficient challenge through graded intervention specific to each athlete's skill level assisted athletes in fine-tuning their visual and sensory systems to promote efficiency in sport.

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