



Full length article

Effect of four weeks of ocular-motor exercises on dynamic visual acuity and stability limit of female basketball players

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ARTICLE INFO

Keywords:

Visual exercises
Balance
Basketball
Oculo_motor

ABSTRACT

Introduction: Visual skills are an integral part of most daily activities and an effective indicator of the functional ability of athletes, particularly in the fields of dynamic sports like basketball. Despite the important role of vision and effect of ocular exercises on functional skills in athletes, a few studies have been conducted in this regard. Thus, this study aimed to investigate the effect of ocular-motor exercises on dynamic visual acuity and stability limit of female basketball players.

Methods: In this semi-experimental study 30 club elite female basketball players aged between 18 and 24 years, with at least three years of specialized basketball experience, were randomly assigned to two intervention and control groups. The athletes in the intervention group participated in the designed four-week program (six sessions per week) of the oculo_motor exercises. The control group did just their own daily routine exercises. The limit of stability was measured by the Biodex balance system SD and dynamic visual acuity was measured by the PowerPoint, which is for detecting dynamic visual acuity. Also, the SPSS software version 19 was used to analyze the data by using descriptive statistics methods: independent t and Paired t tests, at a significance level of $P \leq 0.05$.

Results: The results showed that doing four weeks of the oculo_motor exercises led to a significant increase in the overall stability index (OSI) from $28/66 \pm 7/23$ to $51/60 \pm 6/38$ ($p = 0.001$), as well as in dynamic visual acuity from $29/73 \pm 4/19$ to $56/20 \pm 8/81$ ($p < 0.001$); in the intervention group, these changes were also statistically significant in comparison with the control group and before doing the exercise protocol ($p < 0.05$).

Conclusion: According to the obtained results, the oculo_motor exercises can be used to enhance the limit of stability and dynamic visual acuity in basketball players and other dynamic sports.

1. Introduction

Basketball is a dynamic sport, in which the players are constantly moving and taking a new position every moment [1]. This displacement requires a re-analysis of visual information obtained from the new position, dynamic visual acuity, keeping balance, and controlling posture [2]. Basketball skills are based on the correct functioning of the

visual system in addition to the physical fitness and specialized skills [3]. During this process, a basketball player focuses his eyes on the spatial position of the ball with environmental awareness of other players [1]. In fact, the sense of sight measures the orientation of the eyes and head towards the surrounding objects and plays an important role in keeping balance [4]. In order to attain the visual information, the eyes should be considerable time fixed on the ball before touching it

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<https://doi.org/10.1016/j.gaitpost.2019.06.022>

Received 24 January 2019; Received in revised form 2 April 2019; Accepted 27 June 2019

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with hand. Therefore, in order to create enough time to fixation and consequently the processing of visual information, object deployment should be done as soon as possible with the advent of an object or its quick movement or sudden change of position [1]. In such situations, the vestibulo-ocular reflex plays an important role in the coordination between the eyes and the hand [1,5]. Also, changing the head position leads to the activation of the atrial system and a change in the distribution of postures in the neck and organs influenced by the vestibulo-spinal and vestibulo-ocular reflexes [6].

Fast tracking the ball with eye is very important in the professional basketball game. In this sport, the dynamic visual acuity has a significant effect on the performance of athletes in addition to the static visual acuity [7]. Dynamic visibility refers to the clear vision of the athlete while moving or when the athlete follows an animated object [8]. Dynamic vision is very essential in dynamic sports such as basketball, volleyball and motorcycles [9].

Several studies have been conducted on whether vision skills are inherent in athletes or improved by regular practice [10]. In fact, the visual system responds to the loading principle like the musculoskeletal system [1,8]. Studies show that doing visual exercises results in an improvement in both vision skills and sport performance [11,12].

Ocular-motor can be mentioned as one of the visual exercises (Fig. 1). These exercises include neuromuscular control skills, which have evolved for the focus of vision system on the target and smooth pursuit for the moving target or one target jumping on another target [13]. The components of ocular-motor exercises include fixation, saccadic movements, smooth pursuit, and optokinetic and vestibular movements [3]. Saccadic and smooth pursuit movements of the eyes are important and essential in many aspects of sport [13]. Although dynamic visual acuity and the limit of stability are of the greatest importance, no study has been conducted on the effect of ocular-motor exercises on athletes to date. Therefore, the objective of the present study was to investigate the effect of oculo_motor exercises on dynamic

visual acuity and limit of stability in female basketball players.

1.1. Methods

The current research is a clinical trial study. Thirty club female athletes with at least three years of continuous activity in basketball, with normal vision and hearing and the age range 18–24 years, were entered the study. The participants did not have a history of a direct blow to the neck or upper limb during the past month, lower limb injury in the last six months, history of drug consumption affecting neuromuscular function, acute and specific pains affecting the process of the test run. The people with musculoskeletal disorders affecting balance (forward head Posture), neuropathy, diabetic foot, dizziness and the problems related to the vision including refractive errors disorder, history of ankle fracture, double-sided ankle sprain, ankle injury in six months before the time of the research (history of ACL knee injury), performing surgery in the lower limb or participation in other rehabilitation programs, which were simultaneous with the present research, were excluded from the study [14]. Ethics approval was taken from the Research Ethics Committee for Tehran University of Medical Sciences, and all the participants were given a written informed consent. Then, the subjects were randomly divided into two intervention-control groups. The practice group did the exercises six days per week in the morning and evening during four weeks (morning exercises were done at home and evening exercises were done at the club). During the research, the control group maintained their own activity levels prior to participating in the study. The height and weight of each subject were measured using a Seca digital scale (model 703). In the pretest, PowerPoint and metronome were used to measure dynamic vision [4] and Biodex was used to measure the limit of stability [15]. It should be noted that all measurements were done before and after the exercise protocol (Table 1).

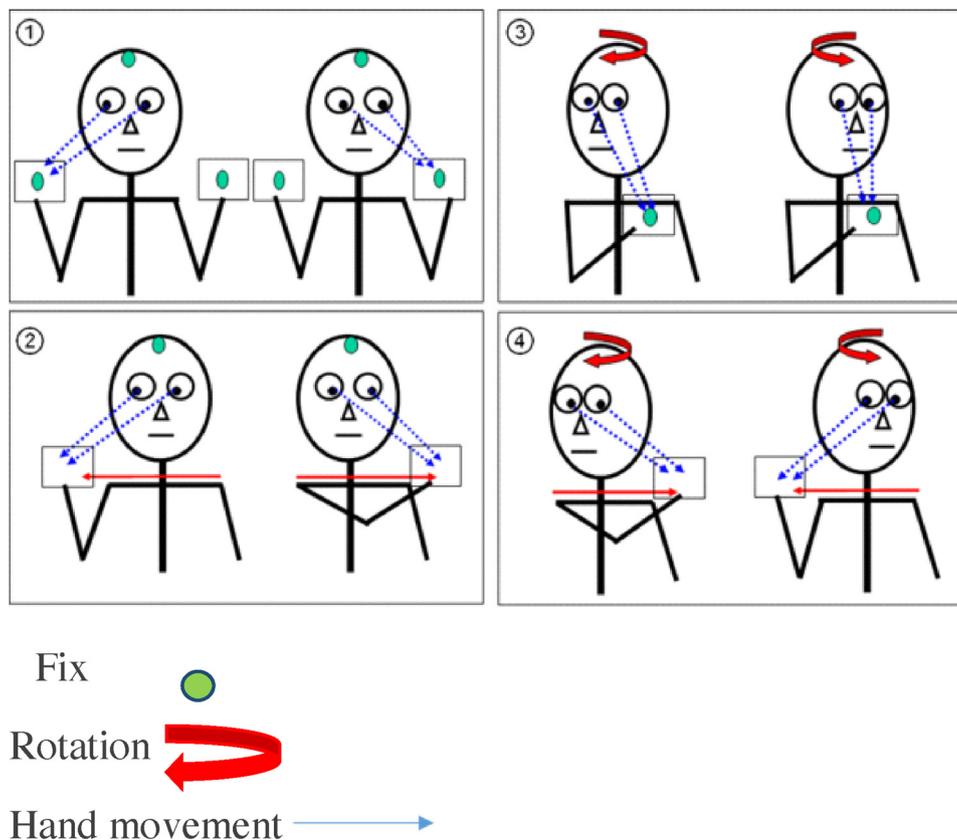


Fig. 1. Oculo-motor exercises and gaze stability exercises.

Table 1
Description of the oculo-motor and gaze stability exercises [4].

Num	Kind training	Train
1	saccadic eye movement	The subject moving the eyes horizontally between two stationary targets while keeping the head still
2	smooth pursuit	The subject Moving the target horizontally and tracking it with the eyes while keeping the head still.
3	adaptation X1	The subject moving the head horizontally while keeping the stationary target in focus
4	adaptation X2	The subject moving the head and target in opposite directions horizontally while tracking the target with the eyes

Table 2
Comparison of baseline data between groups.

Variable	Groups	SD ± Mean	p-value
Age (year)	Experimental group	20/13 ± 1/27	0/30
	Control group	35/20 ± 28/1	
Height(cm)	Experimental group	13/169 ± 1/55	0/63
	Control group	169 ± 78/1	
Weight (kg)	Experimental group	62/33 ± 3/71	0/80
	Control group	3/61 + 61/04	
BMI	Experimental group	21/86 ± 1/31	0/23
	Control group	88/1 ± 55/21	

1.2. Measurement of the limit of stability

In order to measure the limit of stability, a Biodex Balance System SD (USA) was utilized. The intraclass correlation coefficient of this device ranged from 0.64 to 0.89. The subject's status when standing on the Biodex balance device was as follows: both feet were on the balance sheet, both hands were on the side of the body, and the trunk was straight and the subjects held their heads with open eyes opposite the monitor of the device. The test was repeated three times for 30 seconds and the rest interval between each repetition was considered to be 10 seconds. This test was done at difficulty level II. Also, the overall stability index and the time to reach balance were considered as the limit of stability [15].

1.3. Measurement of dynamic vision

In fact, dynamic vision is defined as the ability to detect details when there is a relative movement between the observer and the target object. It was measured by reading the numbers during neck rotation. A PowerPoint containing 10 slides, each of which randomly had 5 numbers, was used to measure dynamic vision (the size of all numbers was 12 to 20 at the center of the page). Each page had 5 numbers with the same font and each person evaluated 10 pages. The person sat down on the chair and was placed centimeters at a distance of 70 cm of the paper at same level with the eye. The person was asked to rotate the neck with a frequency of 2 Hz to see the numbers (the pain in the rotation of the neck was 70 degrees with a frequency of 2 Hz). Also, the person was asked to maintain approximately the frequency of 2 Hz during testing using the metronome and verbal feedback. The dynamic vision score of the person was calculated based on the number of correct answers. The person had 5 seconds to answer the questions on each page during the rotation of the neck. Before doing the test, it was confirmed that all the individuals were able to read the smallest font size 12 at a distance of 70 cm without moving head [16].

Table 3
Comparison of dynamic visual acuity before and after exercise program.

Variable Statistics	Groups	Mean ± SD	p-value
Pre DVA (% In Correct)	Between groups	56/20 ± 8/81	0/94
	Within groups		
Post DVA (% In Correct)	Between groups	29/73 ± 4/08	0/00*
	Within groups		
	Experimental	56/00 ± 7/05	
	Control	53/46 ± 7/14	

2. Training protocol

The athletes in the intervention group performed these exercises in the sitting position for four weeks (six sessions per week) for 10 min in the morning and evening. During doing the exercises, the individuals were taught to focus on the purpose that they kept in their hands and moved the head and target quickly to the extent that they could clearly see the image. Each week, two repetitions were added to the number of them. Ten seconds of rest between two sets of the training sessions and five seconds of rest between two moves were considered [17].

2.1. Statistical analysis

After ensuring the assumptions of the normality of the data distribution with the Shapiro–Wilk, ANOVA was used to compare the variables within and between groups. All analyses were performed using IBMSPSS Statistics version19.0. And, significant level was considered less than 0.05.

3. Results

As shown in Table 2, the results of Independent t-tests indicated that there was no significant difference between the two groups in terms of height, weight, age and body mass index (P < 0.05) and the two groups were homogeneous.

Also, the results of ANOVA (Table 3) showed that there was a significant difference between and within groups: change of dynamic visual acuity in the experimental group (P ≥ 0.05), but there a significant difference between the pre-test and post-test in the control group was not observed (P < 0.05).

Moreover, the results of ANOVA showed that there was a significant difference among the intra-group changes of the overall stability index in the limit of stability in the group of ocular-motor exercises (P ≥ 0.05) (Table 4), but there was no significant difference in the control group between the pre-test and post-test (P < 0.05).

4. Discussion

This study was designed to investigate the effect of ocular-motor exercises on dynamic visual acuity and limit of stability in female basketball players. There was a significant difference between the dynamic visual acuity and the overall stability index in the limit of stability in the intervention group after doing these exercises (P < 0.001).

The literature review revealed that limited studies have been conducted on the effect of ocular-motor exercises on dynamic visual acuity and the limit of stability. The only study in line with the results of the current research is the study by Morimoto et al., who worked on

Table 4
Comparison of Limit of stability before and after exercise program.

Variable Statistics		Groups	Mean \pm SD	p-value
Limit of stability Pre	Between groups	Experimental	28/66 \pm 7/23	0/95
	Within groups	Control	29/60 \pm 9/55	
Limit of stability Post	Between groups	Experimental	51/60 \pm 6/38	0/00*
	Within groups	Control	31/73 \pm 8/51	

healthy non-athlete individuals; the researchers reported that dynamic visual acuity and limit of stability of healthy individuals had a significant progress after doing three weeks of ocular-motor exercises [4].

The study by Meshkati et al. can also be mentioned, in which the role of vision in postural stability was investigated; this study compared the role of vision in static postural stability in athletes and non-athletes. In this study, 25 non-athletic males and male karatekas (25 people) participated in this study. The force plate was used to do the static balance test. The results showed that when the participants closed their eyes, height fluctuations increased and the middle-lateral speed was higher in athletes than non-athletes [18]. The results of the study by Mousavi et al. showed that removing the eyesight worsened the balance in male swimmers [9]. The most disorder of maintaining sustainable height happened in the status of non-use of vision in the anterior-posterior direction. However, in the study by Paillard and Noé, it was found that, in national football athletes, intense exercises led to the lower attachment of these athletes to the importance of vision in postural control and the effect of the allocation and distribution of vision in posture was less in the professional athletes than non-professional athletes [11].

In fact, the extent of dynamic visual acuity to organize the moving ball while the athlete's head is moving is essential and important for a basketball player [19]. On the other hand, balance begins from the vestibular nerve and then it goes to cerebellum and vestibular nuclei in the brain and it goes to reticular nuclei in the brain stem and also to brain via the vestibulospinal and reticulospinal pathway. This control is very important while sport skills and physical activity are performed [20].

Due to quick movements in exercise, the importance of visual skills is multiplied and the person needs a suitable dynamic vision to focus on the visual field. Therefore, dynamic vision information becomes important for ease of detection of processing speed and movement [21].

In justifying the results obtained from the effect of doing these exercises on the improvement of dynamic visual acuity and the limit of stability in the intervention group, fixation can be mentioned as one of the components of ocular-motor skills. In fact, in basketball this skill is very important in order to focus on throw the ball into the hoop. Fast tracking the ball by the eyes is very important in the professional basketball game [22]. Saccadic movements are the fastest ocular movements, which are performed by the ocular motor system [23]. Saccadic eye movements lead to a decrease in the body fluctuations, but following a moving point results in an increase in the body fluctuations [24]. However, how two types of ocular movements (fixation and saccadic) affect postural stability, especially for eye tracking movements, is ambiguous [5].

Considering that basketball is a dynamic sensory and motor sports and changes in the fixation point in basketball is very fast, therefore, an athlete needs a correct and fast saccade movement with a low latency. Studies have shown that continuous sports visual exercises help to increase the ability of visual skills in athletes [8,12].

The effect of the visual system on postural control has been emphasized in several studies [25,26]; this can be due to the connection between the three systems of visual, vestibular, and somatosensory [27]. The results of this study also showed that ocular-motor exercises have had a significant effect on the progression of the limit of stability in female basketball players.

Postural and visual stability depends on the afferent visual-auditory and deep sense. This afferent is under the influence of multi-receptors in the brain regions to provide effective outputs to maintain the posture and control ocular movement. Inaccurate information in result of a disorder in sensory receptors leads to instability in vision and posture and mismatch of receptors [27]. The visual system plays an important role in postural control and the amount of postural fluctuations increased in the absence of vision [28].

Lisberger et al. emphasizes that there are some communication examples of the relationship between motor function and visual behaviors; thus, the longer the person was exposed to the dynamic conditions of exercise, the dynamic visual skill increased [29].

Studies have illustrated that the ocular-motor activity activates those areas of the brain which have a positive effect on the ability to balance, while it has no effect on balance when the vision is blocked [30].

According to many researchers, retinal stimulation location is very important in control balance. Another theory presented by Gibson expressing that not only retinal stimulation location and sensitivity, but also radiation geometric building, which forms radiation field of vision, play an important role in postural setting as visual data [31].

5. Conclusion

According to the results of this study, it can be recommended to basketball coaches to do ocular-motor exercises along with other specialized exercises in this field. Moreover, it can be suggested to other researchers to do this study in other sport fields and head movement exercises with closed eyes in control group.

Funding

This project has been financially support for data gathering by Tehran University of Medical Sciences (Consultant contract no: 97-02-30-35665).

Declaration of competing interest

None of the contributing authors have any conflict of interest that may have biased this work.

Acknowledgments

We would like to thank all contributors to this project. Special thanks for all contributors of the project at district and provincial levels who make this project possible.

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