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***Original article***

# THE EFFECT OF SPORT ON BALANCE FUNCTIONS

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**Abstract**

*Aim:* Postural control involves the ability of the central nervous system (CNS) to integrate and select sensory inputs from the somatosensory, visual, and vestibular systems, and to generate proper motor outputs. Furthermore, fine control of posture is a crucial component of motor skills which plays a significant role in success of athletes of various sports. The vestibular system contributes to postural stability and visual stabilization through the vestibulo colic reflex (VCR), vestibulo-spinal reflex (VSR) and vestibulo-ocular reflex (VOR), respectively. The VSR produces contraction of anti-gravity muscles to help maintain postural stability while the VOR produces eye movements to maintain clear visual acuity during head movements. Sports can improve the usage of these data from different sources. Nevertheless, some sports are mostly dependent on eye tracking, while some sports are not. The objective of this study is to investigate the effects of sports on a population without balance complaints and to detect the effect of different sport activities on vestibular rehabilitation planning.

*Methods:* For this study, 16 sportsmen who play sports involving eye tracking (tennis, basketball, volleyball, etc.), 16 sportsmen who play sports which do not involve eye tracking (swimming, running, body building, etc.) and 16 individuals who do not play sports will be chosen. Computerized Dynamic Posturography (Sensory Organization Test and Adaptation Test) and Video Head Impulse Test (vHIT) will be performed on these individuals to evaluate and compare their balance and vestibulo-ocular reflexes. The 32 sportsmen involved in the study had to have been playing sports for at least 5 years. To be included in the study the participants' exclusion criteria are: having balance disorders, auditory disorders, neurological deficits, sensory disorders, and musculoskeletal disorders, cardiovascular problem that might influence balance performance, injury in the past 12 months that required medical attention, cerebral concussion and cognitive deficits

*Results:* The six different were evaluated and significant differences were found in conditions 1, 2 and 4 in SOT. There was also a significant difference between the group without eye tracking and the control group in the left lateral semicircular canal with vHIT test.

*Conclusion:*While athletes engaging in sports with eye tracking have been found to have improved balance in the SOT (condition 4) of CDP, we found that the sport had no effect on VOR gains.

*Keywords:*posture, sport, VOR, computerized dynamic posturography, video head impulse test.

## Introduction

Balance was once defined as the ability to hold our body properly upright. Nowadays balance is the ability to adjust ones center of gravity while standing/sitting and while moving with the help of our feet. (Hansson, Beckman, & Håkansson, 2010; Nashner, Shupert, & Horak, 1988) To maintain continuous balance; visual, somatosensory and vestibular organs work together. Inputs from the environment have to be integrated in the central nervous system and the processed information has to be stored.(Hansson et al., 2010; Möller C., 1989)

The vestibulo ocular reflex (VOR) stabilizes the gaze and allows special orientation in the retina during the rotation and translation of the body. The three dimensional processing of VOR is allowed by the simultaneous function of the semicircular canals, otolith organs as well as the oculomotor system that is coordinated by the central nervous system. (Raphan &Cohen, 2002) The cervico ocular reflex works with the VOR and gives us information about the head movements regarding the body position. (Hansson et al., 2010; Karlberg, 1995)

Information from different points of importance are continuously interpreted and a motor answer is created to maintain balance. This means that the body is always in a state of movement that is called postural sway.(Hansson et al., 2010; Rogind, Lykkegaard, Bliddal, & Danneskiold-Samsoe, 2003)Postural sway increases when the eyes are closed and when there is visual inputs. (Era et al., 2006; Hansson et al., 2010; Tsutsumi et al., 2009) Moving the head, keeping it in a

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tilt position and impairment of the cervical proprioception are other factors that affect postural swat negatively. (Hansson et al., 2010; Paloski et al., 2006; Patel, Fransson, Karlberg, Malmström, & Magnusson, 2009) Furthermore, less information about the pressure coming from the feet can increase lateral postural sway. (Hansson et al., 2010; Magnusson, Enbom, Johansson, & Pyykkö, 1990)

Visual attention plays a very important role in sports. Athletes playing team sports follow the game with their movements and positions simultaneously. (A.M. Williams, K. Davis, 1999; Abernethy, 1990; Nougier & Rossi, 1999) In many team sports (football, hockey, basketball etc.) tracking the game is key for a successful one. (Memmert, Simons, & Grimme, 2009) Athletes become successful in their respective sports with self-controlled learning and conscious trainings. (Zhang et al., 2016) With these training programs the balance functions and systems, especially in young athletes improve. (Fong et al., 2014) In our study our main goal is to prove that visual tracking is important in different groups of sports with VOR gains and variant balance components.

**Material and Methods**

This was a study to assess the different components of balance between two different groups of athletes using two different test methods. This study was approved by the ethical review board of Istanbul Medipol University (date: 25/04/2018 no: 264). The tests were conducted at the Audiology Department at the Istanbul Medipol University Medipol International Health Center. Being a participant was voluntary and all the participants signed a consent form with detailed explaining of the procedures and tests. All the patients were tested between April 2018 – June 2018. The patients were evaluated with Video Head Impulse Test (vHIT) and Computerized Dynamic Posturography and their results were recorded.

Two different athlete groups (Group 1 and Group 2) and one control group each having 16 participants between the ages of 18-25 were selected for this study. The inclusion criteria were: to be between the ages 18-25, to have normal hearing thresholds,to not have any neurological, internal and/or ear nose and throat illnesses, to not have any diseases that would affect their balance, to have a continuous history with their respective sports for at least five years (control group not included), to practice their respective sports at least two times a week(control group not included) and to voluntarily participate in the study. Any volunteer not meeting the inclusion criteria were excluded from the study.

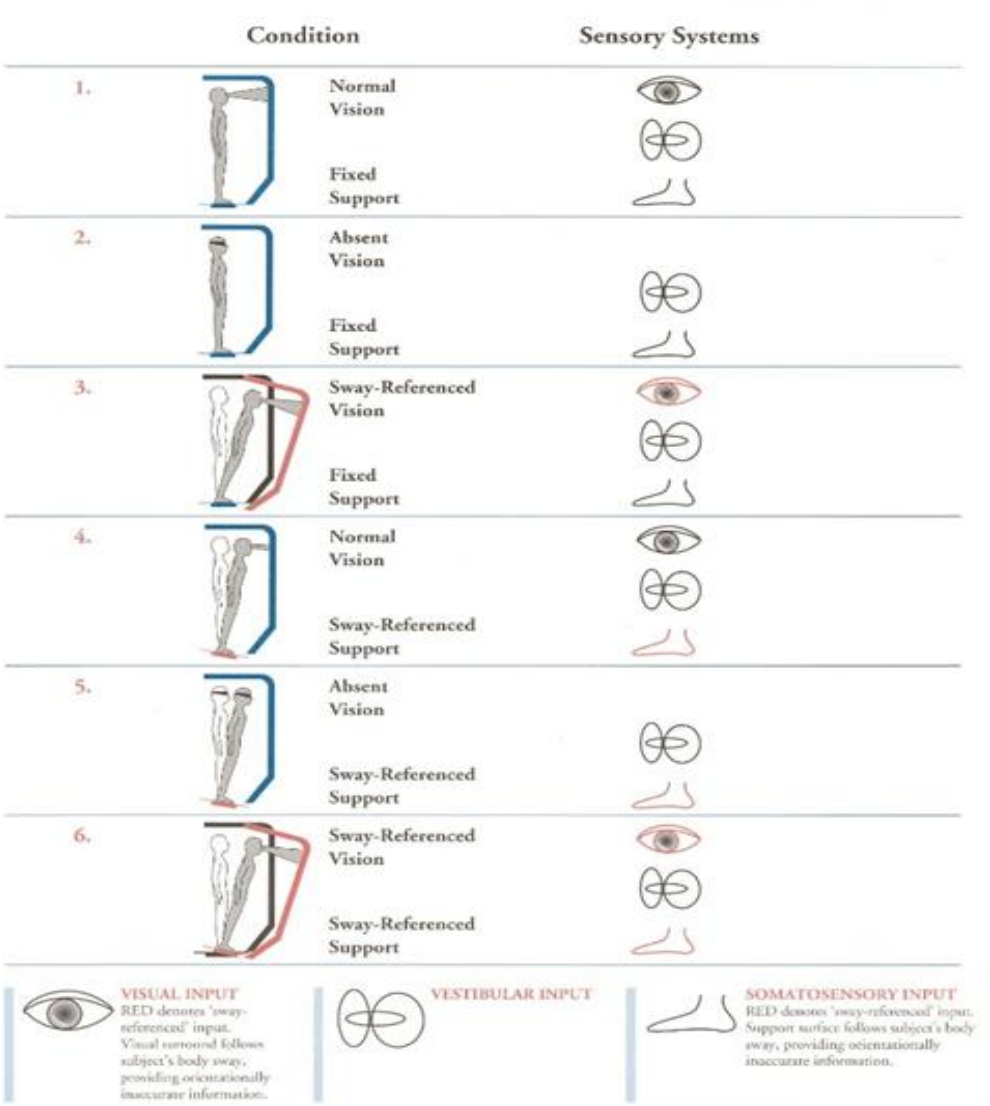
While almost every sport improves balance, each of them affect a different place. In our study we studied the effect of VOR in different sports and its effect on balance. To asses VOR we used one group of athletes doing sports regarding eye tracking, one group without eye tracking sports and one control group with participants not engaging in any sports. Group one consisted of 16 patients that were athletes of sports that included a ball. The reason for this is to have athletes that have eye tracking movements in their normal life. Group two consisted of 16 athletes that did not participate in sports containing a ball. The reason for dividing the participants into these two groups is to evaluate sports according to their use of different balance factors and principles rather than conducting a study based on each sport separately.

We used the ICS Impulse version 3.0 vHIT test system by GN Otometrics of Denmark. The vHIT investigates VOR objectively stimulating all three semicircular canals; left horizontal, right horizontal, left anterior, right anterior, left posterior, right posterior. This testing method allows every semicircular canal to be evaluated separately. We fastened a pair of goggles to the participant and calibrate it accordingly for each participant. During the testing process we asked them to look at a marked spot. When the participants` eyes were fixed on the spot we moved their heads` in sudden movements in the specific plane to test the wanted semicircular canal.

Computerized Dynamic Posturography (CDP) is a test method that evaluates dynamic balance and assesses patients with vestibular disorders and/or neurological deficiencies. NeuroCom Balance ManagerComputerized Dynamic Posturography was conducted to all the participants. Sensory Organization and Adaptation Tests were used to assess the participants` balance functions.

The participants were asked to continue their everyday lives. They were told not to engage in extra practice for this study as it may have affected our test results. We did not perform any activities and/or medical treatments that may affect the participants` balance before or during the study.

Figure1. Sensory Organization Test (SOT) - SixConditions




**Statistical Analyses**

The statistical analysis for this study was conducted with the IBM Statistical Package for the Social Sciences with the version 25.0. We used Kruskal-Wallis for three way and Mann Whitney U for two way analyses. We also performed Bonferroni Correction to find the significance of our variables.

**Results**

The six different conditions in the SOT test were evaluated with the Kruskal Wallis Test and significant differences were found in conditions 1, 2 and 4. With Mann Whitney U test we found that there was significant difference between the control group and group 1. Regarding SOT significant difference was found between groups 1 and 2 in conditions 1 and 4. In composite data control group was significantly different than group 2. (Table 1)

While visual data were not significantly different in SOT, we have observed clinical differences. Group 2 is significantly different than the control group regarding the adaptation toes-up test. (Table 2) There was also a significant difference between group 2 and the control group in the left lateral semicircular canal with vHIT test. (Table 3) There were no other significant differences with any other test comparisons. (p>0,05)

Table 1. SOT variables evaluated with Mann Whitney U

| | GROUPS | N | Mean Rank | Sum of Ranks | Sig. (2-tailed) |
|---|---|---|---|---|---|
| Trial 1 | Athletes With Eye Tracking | 17 | 16,41 | 279,00 | 0,007 |

| | | | | | |
|---|---|---|---|---|---|
| | Athletes Without Eye Tracking | 9 | 8,00 | 72,00 | |
| Trial 2 | Control | 20 | 17,63 | 352,50 | 0,13 |
| | Athletes Without Eye Tracking | 9 | 9,17 | 82,50 | |
| Trial 4 | Athletes With Eye Tracking | 17 | 16,59 | 282,00 | 0,004 |
| | Athletes Without Eye Tracking | 9 | 7,67 | 69,00 | |
| Composite | Control | 20 | 17,55 | 351,00 | 0,016 |
| | Athletes Without Eye Tracking | 9 | 9,33 | 84,00 | |

Table 2. Adaptation Test variables evaluated with Mann Whitney U

| | GROUPS | N | Mean Rank | Sum of Ranks | Sig. (2-tailed) |
|---|---|---|---|---|---|
| Toes Up Down | Control | 20 | 11,55 | 231,00 | 0,001 |
| | Athletes Without Eye Tracking | 9 | 22,67 | 204,00 | |

Table 3. Video Head Impulse Test variables evaluated with Mann Whitney U

| | GROUPS | N | Mean Rank | Sum of Ranks | Sig. (2-tailed) |
|---|---|---|---|---|---|
| VOR Gain for Left Lateral | Control | 20 | 12,45 | 249,00 | 0,06 |
| | Athletes Without Eye Tracking | 9 | 20,67 | 186,00 | |

Discussion

Postural control is the ability to select and integrate somatosensory, visual and vestibular system outputs to the central nervous system and generate motor outputs according to the situation. (Fong et al., 2014; Jacobson, Newman, & Kartush, 1997)

The VOR system is enabled when the head movements are too fast and vision starts to blur. Under normal conditions with slow eye tracking the smooth pursuit system is the one that works. When these two systems don't work on focusing on the target, sudden saccadic eye movements ensure that the eyes position towards the target.

Visual and postural balance systems are very different regarding their working mechanisms. This is because these two systems get stimuli from different muscle movements and act to stimuli coming from different neural pathways. Visual stability is very hard to maintain when one of the head, body or eye mechanisms don't work properly, because of this visual and postural balance systems work with each other. Visual balance regarding target tracking is one of the most important sensory inputs regarding postural control. (Peters, 2007)

Maintaining balance is quite hard when one of the somatosensory, visual or vestibular inputs are damaged. (Del Percio et al., 2007) Janky et al (2018) found that patients with vestibular loss exhibit low gain results in vHIT. (Janky et al., 2018) CDP is used to rehabilitate patients with vestibular disorders and/or neurological deficiencies. (El-Kashlan, Shepard, Asher, Smith-Wheelock, & Telian, 1998) Harstall performed rehabilitation this way in a study to patients with stroke, head trauma and amputation. (Harstall, 1998)

Athletes train regularly to improve their skills. These training sessions are known to be very effective in improving their balance systems. Several studies have been conducted regarding different sports to investigate balance and sensory inputs organizations.(Alpini, Mattei, Schlecht, & Kohen-Raz, 2008; Bringoux, Marin, Nougier, Barraud, & Raphel, 2000; Golomer, Crémieux, Dupui, Isableu, & Ohlmann, 1999) For example Golomer et al. conducted a study on dancers on 1999 and it was seen that they relayed on somatosensory inputs the most to protect body posture. Bringoux et al. (2000) performed a study on gymnasts and the same results were shared. In 2008 Alpini carried out a study on ice skaters. It was seen that ice skaters trusted their vestibular inputs more for balance. Perrin, Deviterne & Hugel (2002) discovered that judoidts used their somatosensory systems more for balance. Del Percio et al (2007) conducted a study

on karate players. They saw that karate players` serebral integration center, integrating somatosensory, visual and vestibular systems, were better than the control group. Fong et al. (2012) saw that kae kwan doe players were better at one-legged standing and had better vestibular function compared to the control group.(Fong et al., 2014)

## Conclusion

We found an inverse proportion with the balance scores and VOR gains. Engaging in sports with eye tracking (sports involving balls) have been found to improve balance (condition 4), although they have no positive affect on VOR gains. Carrying out a study with a more diverse test group regarding the participants` ages with more test subjects could have given us more reliable results.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