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Comparison of muscular strength and balance in athletes with visual impairment and hearing impairment

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This study was conducted to compare muscular strength and balance of athletes with visual and hearing impairment. The study was carried out with 20 athletes of national Olympic level sports goalball team and 20 athletes of national Olympic level sports hearing-impaired karate team. Isokinetic muscular strength was assessed by IsoMed 2000 device as concentric-concentric at 60°/sec and 240°/sec. Balance assessment was carried out with the Human Body Equilibrium 360 device. There was no significant difference between groups regarding age, height, weight and body mass index ($P>0.05$). There were no differences between the dominant and nondominant knee flexion and extension peak torque (PT), % of flexion/extension PT ratio, % of dominant/nondominant PT differences at 60°/sec and 240°/sec velocities ($P>0.05$). There was no difference between the groups regarding of both leg static balance ($P>0.05$). However, single leg standing balance was significantly different between groups in favor of athletes with hearing impairment ($P<0.001$). As a result of our study it was determined that muscular strength and static balance of athletes with visual and hearing impairment were similar, but athletes with visual problems are likely to have lower levels of single leg balance. Strategies to promote single leg balance in athletes with visual impairments are warranted.

Keywords: Balance, Disability, Goalball, Karate, Muscular strength, Sport

INTRODUCTION

Individuals with sensory impairments restrict from participating in physical activities and their physical activity level, muscular strength, cardiovascular endurance, balance, and sports performance are decreased (Akınoğlu and Nezire, 2018; Karakoc, 2016a; Karakoc, 2016b). However, sport activities improve the physical fitness and psychomotor abilities of these individuals, thereby enabling them to acquire the skills of daily living, orientation, and mobility (Yildirim et al., 2013).

Visual and hearing impairments are associated with increased risk of mortality in adulthood. One potential pathway explaining this association is reduced levels of physical activity across the lifespan (Rajala et al., 2000; Smith et al., 2015). A certain level of physical fitness is essential for the performance of sport-specific activities in many sport branches. Muscle strength which is one of the physical fitness parameters, is needed to outperform the competitor against the athlete (Clark and Mesch, 2016; Karakaya et al., 2009). Balance, the ability to maintain the equilibrium of the body, is maintained, controlled, and monitored by a multisensory system, consisting of the vestibular, visual and somatosensory system (Cohen, 2013; Grace Gaerlan et al., 2012). Adequate balance depends on the integration of these neurophysiological systems, the inadequacy of these systems negatively impact the balance (Wiszomirska et al., 2015). Vision and hearing ability are considered the most crucial sensory input in the process of maintaining postural control (Teasdale and Simoneau, 2001). Any impairment in visual perception and ability of hearing affects the maintaining of balance as a result of the damaged vestibular system and the deterioration of the connections between the neural structures in

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the upper centers (Zebrowska et al., 2007).

Awareness about sports activities for persons with an impairment have increased over the years (Lieberman et al., 2002). Goalball has become most widely known team sport among the individuals with visual impairment (Lieberman et al., 2002). At the same time, individuals with hearing-impairment also participate in different kinds of sports such as karate (Lieberman et al., 2002). In both sport branches muscular strength and balance are crucial parameters for better performance (Clark and Mesch, 2016; Karakaya et al., 2009).

Although there are several studies investigating the muscular strength and balance of healthy group (Sculthorpe et al., 2017; Thomas et al., 2015) and athletes (Ambegaonkar et al., 2014; Hammami et al., 2016) there are very few studies comparing muscular strength and balance of athletes with visual and hearing impairment (Gawlik and Zwierzchowska, 2006). The aim of this study is to investigate whether there is any difference between muscular strength and balance of athletes with visual impairment and hearing-impairment and how the type of disabilities effect on these parameters.

MATERIALS AND METHODS

The study was conducted with the aim of comparing the knee flexion/extension isokinetic muscular strength and balance of athletes with visual impairment and hearing-impairment.

Ethical clearance

This study was designed according to the Declaration of Helsinki. All the athletes and coaches who accepted to participate in the study were fully informed about the study purpose, the assessments included in the study, the benefits of the study and all the athletes signed written informed consent.

Setting

Center of Athlete Training and Health Research.

Participants

The study was carried out with 20 (11 males and 9 females) athletes of national Olympic level sports goalball team (the visual impairment level is between the B1–B3) aged between 17–29 and 20 (11 males and 9 females) athletes of national Olympic level sports hearing-impaired karate team aged between 18–28 who complied with the inclusion criteria and voluntarily participated in the study. The inclusion criteria for the study included not having any systemic problem or any health problem except their impairment and having cooperation for testing. The potential benefits of the study are explained to athletes and communication with the athletes was provided by translators who fully fluent in both sign language and spoken language, also currently working with the team.

Procedure

Isokinetic muscular strength assessment

Isokinetic muscular strength was assessed by IsoMed 2000 (D. & R. Ferstl GmbH, Hemau, Germany) device. Prior to the test, the athletes did structured warm-up protocol for 10 min. Considering every athletes' anthropometric feature, the isokinetic device's setting was made following the warming. Joint angles were also set for the assessment by taking range of motion of the individuals into account. The assessment consisted of concentric-concentric knee flexion/extension movement between the angles of 90°–10° flexion. The assessment protocol: the athletes warmed with five repeats of the knee flexion/extension movement at 90°/sec for familiarization and comprehension of device mechanism. Following this, athletes performed 5 repeats of maximal knee flexion/extension movement at 60°/sec and 15 repeats of maximal knee flexion/extension movement at 240°/sec velocity, the sequence of the angular velocity is chanced depending on their randomization. Athletes rested for 1 min between each angular velocity. The assessments were made bilaterally for each joint. First the dominant side was assessed and 3 min later the nondominant side was assessed. The dominant lower limb was defined by the athlete as the leg that was predominantly used to kick the ball (Chiou et al., 2013). The knee flexion and extension peak torque (PT), % of flexion/extension PT ratio, % of dominant/nondominant PT differences at 60°/sec and 240°/sec velocities were noted (Akınoğlu and Kocahan, 2017).

Balance assessment

Balance assessment was carried out with Human Body Equilibrium 360 (HUBER 360, LPG Systems, Middx, France). As balance tests, stability tests were evaluated how much a person can hold his position during 50 sec. During the test, the length and the area that athlete drew away from center line and speed parameters in these changes were determined. Single leg balance tests were also performed. During this test while athlete's one leg was positioned in knee flexion, other leg's which was on the ground, length and area measurement was determined in center changing period during 30 sec.

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Statistical analysis

All the data obtained from the measurements of athletes were analyzed with IBM SPSS Statistics ver. 22.0 (IBM Co., Armonk, NY, USA). Before analyzing the data, the Kolmogorov–Smirnov test was done to determine if the data was normally distributed or not. Because of our data did not show normal distribution, Mann–Whitney *U*-test was used to compare the muscular strength and balance values of athletes. The variables were calculated as means ± standard deviation. The statistical significance was set at $P<0.05$.

Table 1. Demographic characteristics of the athletes who participated in the study

Variable	Goalball athletes (n=20)	Karate athletes with hearing impairment (n=20)	*P*-value[a)]
Age (yr)	23.25±4.05	22.30±2.71	0.302
Weight (kg)	71.80±13.74	65.75±11.03	0.144
Height (m)	1.72±0.10	1.69±0.08	0.408
Body mass index (kg/m^2)	23.92±2.55	22.97±3.64	0.144
Sport years (yr)	11±3.37	12.23±2.87	0.132

Values are presented as mean±standard deviation.
[a)]Mann-Whitney *U*-test.

Table 2. Flexion and extension peak torque Vvlues, H/Q ratio and dominant/nondominant side strength ratio of the athletes

Variable	Angular velocity	Goalball athletes (n=20)	Karate athletes with hearing impairment (n=20)	*P*-value[a)]
Flexion DM PT (N/m)	60°/sec	99.46±32.62	91.18±29.87	0.465
	240°/sec	81.42±27.52	71.66±24.33	0.262
Flexion NDM PT (N/m)	60°/sec	95.40±25.07	91.95±34.56	0.482
	240°/sec	80.51±24.82	74.71±24.28	0.499
Extension DM PT (N/m)	60°/sec	196.35±58.02	163.36±42.82	0.058
	240°/sec	125.22±37.38	106.73±30.29	0.066
Extension NDM PT (N/m)	60°/sec	192.02±59.73	160.31±43.95	0.102
	240°/sec	128.02±40.75	108.32±30.93	0.094
H/Q ratio DM (%)	60°/sec	51.45±4.83	54.13±5.32	0.068
	240°/sec	64.64±8.60	67.03±12.16	0.441
H/Q ratio NDM (%)	60°/sec	51.07±7.49	54.73±6.77	0.057
	240°/sec	63.95±10.22	69.32±12.12	0.156
DM/NDM side flexion (%)	60°/sec	103.40±15.35	101.13±11.29	
	240°/sec	100.66±12.67	95.62±15.92	
DM/NDM side extension (%)	60°/sec	103.22±10.10	102.44±9.30	
	240°/sec	99.26±11.25	98.50±6.43	

Values are presented as mean±standard deviation.
DM, dominant side; NDM, nondominant side; PT, peak torque; H/Q, Hamstring/Qadriceps ratio.
[a)]Mann-Whitney *U*-test.

RESULTS

There was no significant difference between groups regarding age, height, weight, and body mass index ($P>0.05$) (Table 1). Dominant-nondominant knee flexion and extension PT, % of flexion/extension PT ratio, % muscular strength difference of dominant/nondominant side PT at 60°/sec and 240°/sec velocities were similar between the groups ($P>0.05$). The athlete's flexion/extension ratio was within normal limits on both sides at both angular velocities. When comparing knee flexion and extension movement between dominant and nondominant side there was no asymmetry in both groups and in both angular velocities (Table 2). When comparing stability evaluation in eyes opened and closed position, there was no difference between the groups' length and area parameters which athletes drew away from center line and speed parameters in these changes ($P>0.05$). However single leg standing balance evaluation of right and left leg's length and area parameters were significantly different between groups in favor of athletes with hearing impairment ($P<0.001$) (Table 3).

DISCUSSION

To the best of our knowledge, this is the first study to investigate whether there is any difference between muscular strength and balance of athletes with visual impairment and hearing impairment and how the type of disabilities effect on these parame-

Table 3. Balance measurement results of athletes

Variable	Goalball athletes (n=20)	Karate athletes with hearing impairment (n=20)	*P*-value[a)]
Eyes opened stability test			
Length (mm)	755.57±178.94	767.08±391.27	0.256
Area (mm^2)	485.56±101.62	413.04±282.90	0.914
Speed (mm/sec)	15.11±3.57	15.34±7.82	0.262
Eyes closed stability test			
Length (mm)	794.14±246.71	900.76±394.06	0.387
Area (mm^2)	522.49±141.53	435.40±121.12	0.646
Speed (mm/sec)	15.88±4.93	18.01±7.88	0.387
Dominant side single-leg			
Length (mm)	3,047.86±841.76	1,881.69±629.02	0.000**
Area (mm^2)	4,662.06±794.29	1,506.45±973.57	0.000**
Nondominant side single-leg			
Length (mm)	3,116.66±1175.87	1,865.11±579.87	0.000**
Area (mm^2)	7,017.58±1584.92	1,531.82±640.10	0.000**

Values are presented as mean±standard deviation.
[a)]Mann-Whitney *U*-test. **$P<0.01$.

ters. As a result of our study, it was determined that muscular strength and static balance of athletes with visual and hearing impairment were similar, but athletes with visual impairments are likely to have lower levels of single leg balance.

In our study, isokinetic knee flexion - extension muscular strength at 60°/sec and 240°/sec angular velocity were found similar on both sides in athletes with visual and hearing impairment. Although there were several studies investigating the muscular strength and balance of healthy group and athletes, comparison of muscular strength and balance between athletes with visually and hearing impairment has not been made yet (Karakoc, 2016b).

It is also worth noting that studies concluded that agonist/antagonist muscular strength ratios of knee flexion and extension are important since their impairments makes athletes more prone to injury (Knapik et al., 1991). Previous studies have shown that this ratio should be 50%–60% at 60°/sec velocity and 70%–80% at 240°/sec velocity to prevent athletes injuring because of muscle imbalance (Kellis and Baltzopoulos, 1995; Osternig et al., 1983; Şahin, 2010). In our study, it was determined that this ratio was within normal limits at 60°/sec velocity but outside of normal limits at 240°/sec velocity in both groups. It could be concluded that there was a muscular strength imbalance against knee flexors in both athletes with visually and hearing impairment. The incidence of injury of athletes with visual and hearing impairment has been reported to as high as 78% (Magno e Silva et al., 2013a; Weiler et al., 2016). Knee was found to be most common injured joint since 87% of these injuries were knee injuries (Magno E Silva et al., 2013b). Therefore, it seems reasonable to assume that muscle imbalance of the knee joint at the velocity of 240°/sec may be one of the predisposing factors in these frequent sport injuries. In this context, this finding can provide core information about group of athletes with visually and hearing impairment which has not yet been studied in detail.

Difference between the dominant and non-dominant muscular strength were also determined in our study. The study of Kannus (1994) concluded that 10% was upper limit of normal for this difference in isokinetic assessment. In our study, there was no asymmetry between the right and left knee flexion and extension at both 60°/sec and 240°/sec angular velocities in both groups. These findings were in agreement with previous studies in literature.

Adequate balance depends on the integration of multisensory system, consisting of the vestibular, visual and somatosensory system and the inadequacy of which negatively impact (Greve et al., 2013). Therefore, it wasn't surprising that severe hearing and visual loss have been proven to have negative effects on balance and postural adjustment (Karakoc, 2016a; Karakoc, 2016b). Balance is not only an important factor to maintain postural control but achieve healthy body composition and physical fitness to successfully perform sportive activities. Balance is fundamental for dynamic sportive activities which require high speed and agility, but it is require for all kind of sports.

Atasavun Uysal et al. (2010) investigated the effect of loss of vision and hearing on gait and balance in 60 children, 20 of whom had hearing loss, 20 who were visually impaired, and 20 controls with no disability. The gait analysis was performed using a powdered surface while balance of participants was measured with standing balance subtests of the Southern California Sensory Integration Tests. As a result of the study, it was determined that the balance of children with visually and hearing impairment was different in favor of children with hearing impaired. That finding is consistent with our finding indicating that there was significant difference between groups of single leg balance in favor of athletes with hearing impairment. Conversely it was determined that there was no significant difference between groups in static balance in our study. Balance evaluations consisted of different protocols such as static-dynamic tests or with single-double leg. Single leg tests are more sensitive balance evaluation tests since the support surface is reduced. Evaluation with electronic devices which provide more objective data can be more informative about balance difference between groups. Therefore, we believe that significant difference in single leg balance, indifference in static balance in eyes opened-closed position in our study can be result of our objective measurement technique.

The perception of visual and auditory signals of external stimuli from different planes depends on the fact that all structures which are involved to maintain balance are healthy and fully developed (Sadowska et al., 2017). Most important problem in congenital blind individuals is the functional inadequacy of balance centers because of non-being able to perceive an external stimulus visually. Therefore, even if the vestibular system, proprioceptors and antigravity muscles are fully efficient, the absence of visual perceptions will have detrimental effect on the static standing balance or dynamic balance (Karakoc, 2016a; Karakoc, 2016b). In this way perception of vision helps individuals with hearing impairment to develop better motor skill model than visually impaired person. While the hearing-impaired group develops some vestibular compensation strategies for maintain and monitoring balance, fear of independent movement may have prevented the development of compensatory mechanisms in group visually impairment (Atasavun

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Uysal et al., 2010). In this regard, the results of our study coincided with the existing finding of the literature.

Several limitations need to be considered when interpreting the results of this research. One of them athletes with visual and hearing impairment were of different sports. Also, there was no control group to compare. Future studied should focus to compare different sport branches with same disabilities or different disabilities in same sport branches.

In conclusion, the number of people with disability who take part in sport has risen significantly. This study suggests that determination of the muscular strength imbalance and balance in individuals with disability will be a key stone in planning training program for these athletes. As a result of our study, we have determined that type of disabilities does not affect muscular strength. It was also found that athletes have strength imbalance against the endurance of the knee flexors. The single leg balance of athletes with visually and hearing impairment were different in favor of athletes with hearing impairment. We think that hamstring endurance training and balance training with the emphasis of single-leg exercises and should be integrated in the training program of both groups of athletes with visually and hearing impairment but especially for athletes with visually impairment.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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