

RESEARCH ARTICLE

Effect of rock climbing on cervical vestibular evoked myogenic potential, balance, body composition, and functional index in congenitally blind and sighted girls

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Abstract

Background and Aim: Most sighted children spontaneously maintain an adequate degree of physical fitness during the course of normal daily activities. However, blind people are reported to be significantly below the physical fitness norms. The purpose of this study was to investigate the effect of eight weeks of rock climbing on cervical vestibular evoked myogenic potential (cVEMP), balance, body composition, and functional index in congenitally blind and sighted female students.

Methods: In this quasi-experimental study, 10 sighted and 10 blind girls aged 7-12 years were trained rock climbing for eight weeks with three sessions per week, and each session spanned 30 to 45 minutes. cVEMP latencies, dynamic/static balance, right-hand power, leg strength, and body fat percentage were recorded before and after training.

Results: Cervical vestibular evoked myogenic potential in both blind and sighted groups did not change significantly. Dynamic balance, static balance, right-hand power, and leg strength increased significantly in both the groups ($p > 0.05$), whereas the body fat percentage

significantly decreased in both groups.

Conclusion: Eight weeks of rock climbing training led to a decrease in body fat percentage and a significant increase in the functional index in sighted and blind children. This suggests that rock climbing practice can be used as a proper workout protocol for maintaining health and increasing the balance and physical strength of these individuals.

Keywords: Vestibular evoked myogenic potential; blind patients; balance; body composition; rock climbing

Introduction

Blindness is a condition in which the patient does not have visual perception due to physiological or neuropsychiatric factors [1]. Visually-impaired children have needs similar to that of other children, but their impairment limits their activities and postpones their physical growth significantly. Also, the fear of injuries inflicted on them by their parents makes them lose their natural interest in large muscular activities such as running, climbing, and jumping [2]. Visual impairment not only affects the sensory development of vision but also affects all aspects of childhood development [2]. One of aspect of child development is motor functioning of balance and stability, which can be affected by reduction or impairment in vision [3]. In this

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context, open or closed eyes can affect the balance and static of a person while closed eyes reduce standing stability and dynamic and static statuses [3]. Balance is a complex function that comprises numerous neuromuscular processes and is controlled by sensory message, central processing, and voluntary and reflexive motor responses [4].

It is believed that balance is maintained by the inputs of the sensory system, which includes vision, vestibular, proprioceptive, and also cerebellum. Therefore, only a sense cannot keep the balance [5-6]. Due to the lack of information in one of the three sensory inputs in blind subjects, examination of the health and functioning of the vestibular system and diagnosis of the disorders are important [7]. Cervical vestibular evoked myogenic potential (cVEMP) is a tool for examining sacculus, inferior vestibular nerve, and sternocleidomastoid (SCM). It is also used to complete equilibrium tests [8-10] and assess sacculo-collic reflex arc [11]. This reflex begins from hair cells in the sacculus; the signals reach the lateral vestibular nucleus through the vestibular pathway and then reach the SCM muscle through the spinal cord [8,12]. cVEMP is a two-phase (positive and negative) response that occurs in the range of 10 to 25 milliseconds (ms) after the presentation of a high-intensity sound and changes in neck muscle potential. This response is a transient inhibitory response to the activity of SCM muscle. The first wave of response has a positive polarity and appears about 13 ms after the stimulus; this is conventionally called p13. A wave with a negative peak appears about 10 ms after the p13, which is called the n23. These responses are dependent on the vestibular system and, therefore, are found in people with severe sensorineural impairment [8,13]. Since cVEMP does not need vision, it can be used to assess the function of a part of the vestibular system of blind people.

The main components of everyday physical and sporting activities can be divided into two parts of balance maintenance to maintain body position and spatial orientation and the interaction between anatomical components of movement. Since maintaining balance is one of the

indicators for determining the independence of blind people, identifying the factors affecting the changes in balance is one of the subjects considered by researchers to increase the field of autonomy in motion, increase the safety of implementation of daily physical activity and exercise, and prevent damage caused by the fall [14]. There are limited studies in this context that show regular physical activity leads to improved balance in children. In this regard, the implementation of central stability training on static equilibrium, dynamic, and walking speed on 28 blinded students resulted in a significant improvement in the dynamic balance scores and experimental walking speed compared to the pre-centered regression training sessions while no significant change was observed in the control group [15].

Aerobic exercises improve balance in children with visual impairment [16]. Rhythmic exercises (eight weeks, three sessions each 45-minute) conducted among 19 boys and girls (experimental group 10 and control group 9) with low vision led to a significant difference between the two groups in terms of subtle skills, ball skills, static balance, and dynamic balance (walking with high heels and jumping over the yarn) [17]. However, the balance and performance indicators of blind patients have still not been assessed due to research limitations such as limited access to the blind community and difficulty in evaluating their indoor rock climbing workout (IRCW) on cVEMP. In addition, similar research works to study the effect of IRCW programs on the balance of blinded girls have not been carried out in Iran yet. Since IRCW is considered as a skill for preparing for the difficult parts of high-rise climbing, rock climbers usually seek to challenge new paths to develop technical skills, whether they are at an indoor rock climbing surface or outdoor with special rocks. The constant challenge of climbing on unknown routes leads to competitions where all the paths are unknown to the participants and hence, will not have specific knowledge of that particular path. Few researches have been done on the psychological and mental needs of rock climbing at any age,

although the psychological aspects are the key elements in rock climbing [15,18,19]. Thus, the purpose of this quasi-experimental study was to investigate possible differences between the female body composition, right-/left-hand power, strength of leg, muscle thickness, and cVEMP latency as well as dynamic/static balance of blind girls compared to those with normal sight.

Methods

Subjects

This is a quasi-experimental study involving one blind method conducted in two experimental groups with pretest and post-test design in 2016. A sample size of 20 sighted and blind girls (age range, 7 to 12 years) from Mashhad were selected through targeted and available sampling method. The inclusion criteria were being healthy based on the health questionnaire, lack of drug and nutritional supplement consumption, not attending any exercise program (at least 2 months before participating in IRCW program), no history of any balance disorders, no cervical problems such as arthritis, and lack of recognition and response to light. Participants voluntarily participated in the research on the basis of the research conditions and their parents signed the consent form. Then, the samples were randomly divided into two groups: sighted group (n=10) and blind group (n=10). In addition, the steps for tests were approved by the Ethics Committee of Medical Research at the Faculty of Sport Sciences of the Ferdowsi University of Mashhad under the Code 554210 and carried out in February 2016 at Ferdowsi University of Mashhad. The following equation was used to determine sample size:

$$n = \frac{2\sigma^2(Z_{1-\alpha/2} + Z_{1-\beta})^2}{d^2} = \frac{2(2.5)^2(2+1.28)^2}{3.5^2} = 10.97 \cong 11$$

In this equation, the power of the test was 0.8, $\alpha=0.05$ and variation of means was 5. Based on the estimated equation, a sample size of 10.97 was obtained.

The self-report method was used to examine the

subjects' elevation and the Tanner's stage (by the physician). This indicator is based on secondary sexual characteristics that appear during puberty. The subjects did not have mutated growth pattern and no hair growth in private parts, which showed that they had not entered into the puberty stage [1].

Body composition

To assess the body composition of the subjects, their height was measured with a 5 mm sensitivity (SECA height measurement made in Germany with a 5 mm sensitivity), their hip and waist circumference was measured using a tape (Mabis/Japan) with a sensitivity of 5 mm, and the weight of eligible candidates was measured with a digital scale (German Beurer Company, Model PS06-PS07). Then body fat was measured using the impedance bioelectric device (In body-720 / South Korea). Body mass index (kg/m^2) was calculated by dividing body weight by height/meter squared. All measurements were done after the volunteers fasted for four hours and their bladder, stomach and intestines were empty. Subjects were included in the study after cardiovascular examination, blood pressure measurements, and electrocardiogram recordings conducted by physicians. Before exercise, the blood pressure of each patient was measured.

Power test

For measuring the power of hands (Jamar hand Dynamometer), the patient sat on a chair with no handle at the right height, and the shoulder was tested in the adduction state without any rotation, elbows curved at a 90 degree angle and forearm in neutral, wrist between zero and 20 degrees extension and zero to 25 degrees ulnar deviation. The handle of the dynamometer was placed at position No.2, and maximum pressure was applied to the patient's dynamometer handle. The patient's effort was recorded three times and averaged to indicate the strength of each hand. To avoid fatigue, rest intervals of 2 to 3 minutes were considered between the various test cycles.

Balance test

To measure the static and dynamic equilibrium of the subjects, a stork test and a BIODEX dynamometer were used. To do the stork test, the subject needed to lift one of his foot and place the other foot next to the knee of the first leg and place the hands next to the waist. At the signal to start, the subject tries to stay as far as possible in a state of equilibrium, without changing the above conditions. The score of this test equals the maximum time from when the person is on one leg until the loss of balance. The best score is recorded after three movements. The participant cannot use open hands to maintain balance. If at the beginning itself the subject lost balance, then they are given a second chance. To measure the static equilibrium on the two legs, the Sharpened-Romberg test was used. In this test, the subject stands with bare foot and one of the legs (the upper leg) ahead of the other leg and the arms placed in the opposite direction over the chest. The length of time each subject is able to maintain this state with open eye is his privilege [2]. In the dynamic equilibrium test on BIODEX dynamic balance, the range of motion and the degree of rigidity of the balance sheet can be adjusted using the software at 8 various degrees from 1 to 8. In this study, a stable level of 8 was used to balance patients for 15 minutes.

The data were recorded after an announcement in 20 seconds with open eyes. Each test is repeated three times, and the average repetitions are scored as individual scores. There are gaps of 15 seconds between each repetition. The duration of the test was 15 week, and the weekly session was for 48 hours, with all patients starting at level 8, which progressed over time and became harder.

The cervical vestibular evoked myogenic potential test

The cVEMP test was conducted using the ICS Charter EP, powered by the PA-800 portable amplifier manufactured by GN Otometric, USA. The stimulus used to record the response was 500 Hz, with a 95 dB nHL stimulus, a rise, plateau, and fall time of 2-0-2 ms, rarefaction

polarization, and a stimulation rate of 1.5/sec. For the analysis time of 100 ms, a x5000 gain and a 10-1500 Hz bandwidth filter were used. The number of simulations was 150 sweeps per run. In each ear, to ensure repeatability of the response, the test was performed 2 times at each level of intensity. After each test, the person was restored to sitting position to prevent neck and muscle fatigue. The p13 and n23 latencies were recorded and analyzed [20].

Training protocol

The exercise protocol consisted of eight weeks of IRCW, which was performed every week for three sessions, and each session for 30 minutes. Exercise program included getting familiar with the practice of IRCW and explanation on conducting student rehearsal exercises; 5 minutes of general warm-up (stretching); 5 minutes of special warm-up on the stone wall; 5 minutes of IRCW; 5 minutes of rest; again 5 to 1 minute workout, 1 minute rest and 10 minutes to cool down. In order to follow the principle of exercise overload, the practice was added every 30 seconds (Fig. 1 A and B).

Statistical analysis

Descriptive statistics (Mean±SD) were calculated for all variables. After verifying the sighted distribution of the theoretical distribution of data using the Kolmogorov-Smirnov test and homogeneity of variances by the Leven test, statistical analyses of the data were carried out using ANOVA for repeated measure with two groups (sighted and blind group). Differences were considered significant when $p < 0.05$. The data were analyzed using SPSS (SPSS Inc., Chicago, IL) version 16.

Results

The characteristics of the participants in the two are shown in Table 1. There was no significant difference between the two groups in terms of age, height, weight, and body mass index before intervention ($p > 0.05$).

The difference between the pretest and post-test of latency of the myogenic potentials in both the groups was not statistically significant ($p > 0.05$).



Fig. 1. Total rock climbing training protocol in both groups, A) experimental, and B) control.

Intergroup variations showed that there is no significant difference between the effect of IRCW on the latencies of p13 and n23 of the sighted and blind girls ($p < 0.05$, Table 2).

The difference between the means of pretest and post-test of the dynamic balance ($p = 0.001$), static balance ($p = 0.001$), relative power of the right hand ($p = 0.001$), relative power of the left hand ($p = 0.001$), leg muscles strength ($p = 0.001$), and body fat percentage ($p = 0.001$) in both groups were significant (Table 3). There is no significant difference between the effect of IRCW on dynamic balance ($p = 0.15$), static balance ($p = 0.57$), relative power of the right ($p = 0.55$) and left hand ($p = 0.90$), leg strength ($p = 0.23$), and body fat percentage ($p = 0.35$) in both groups.

Discussion

According to the results of the present study, there is no significant difference between the effect of eight weeks of IRCW on the latency of cVEMP in sighted and blind girls. The results of this study are consistent with the findings of Shomeil Shushtary et al. [3], Iwasaki et al. [4], and Rezazadeh et al. [6], but it is inconsistent with the findings of Sandhu and Bell [5] and

Moallemi et al. [7]. The latency of p13 and n23 waves shows the response of sacculus, and the neuronal pathway from the inferior branch of the vestibular nerve to the sternocleidomastoid [8]. It can be concluded that in both sighted and blind groups, the vestibulocolic neural pathway had the same function and the IRCW had no effect on the neuronal transmission time of the waves.

According to the results of this study, the dynamic balance and static equilibrium balance between sighted and blind exercises at the end of the period was significant. These results are consistent with the findings of Shamsipour et al. [15], Ahmadi Barati et al. [14], and Stones and Kozma [13], but it is not consistent with the findings of Buchner et al. [16] and Bellew et al. [17]. The reason for the difference in result is due to the difference between the types of exercises (using IRCW in this research), the intensity and duration of exercises, and the type of subjects. Physical exercises such as those included in this study can cause imbalance in subjects and reduce height fluctuation. These types of exercises lead to deep feelings and can be reinforced with this type of training. Given that in sighted conditions the role of proprioception

Table 1. Mean and standard deviation of the characteristics of the subjects

Group	Mean (SD) Variations			
	Age (year)	Height (m)	Weight (kg)	BMI (kg/m ²)
Sighted (n=10)	11.10(1.44)	1.75(1.02)	39.22(9.71)	18.32(2.55)
Blind (n=10)	9.20(1.75)	1.27(1.16)	25.33(9.61)	15.17(3.44)

BMI: body mass index

and sensory information is much greater than vision and vestibular in maintaining balance, these exercises can be useful for both sighted and blind people. Since the balance of the agent is flexible and changeable, it seems that training interventions in sighted and blind individuals should be focused on several training components [21].

In the present study, one of the reasons for the improvement in the balance of the subjects as a result of IRCW is increasing the strength of the lower muscles of the subjects and performing exercises based on the disorder. Based on this, the exercises were so designed that increasing

the efficiency of deep receptors, relaxing nerve-muscle during cavernous reactions, strengthening the sensory-deepening system, and increasing the strength of the lower limbs can result in greater balance and correct movement of the nervous system [22] while IRCW cannot provide a real disturbing condition for the individual. When the exercise is done at unstable conditions, it improves the efficiency of depth receptors, especially muscle spikes, which sends angular changes to the spinal cord and cerebellum while moving to the spinal cord and cerebellum. IRCW also increases the blood flow to the brain and the efficiency of pyramidal cells

Table 2. Within and between group comparison of latencies of cervical vestibular evoked myogenic potential in sighted and blind groups

Latency	Group	Mean (SD)		p*	p**
		Pre test	Post-test		
p13 right ear	Sighted	11.67(0.86)	11.66(0.72)	0.45	0.45
	Blind	10.96(0.70)	11.38(0.85)		
left ear	Sighted	11.65(0.82)	12.41(1.10)	0.05	0.68
	Blind	10.83(0.53)	11.48(1.01)		
n23 right ear	Sighted	19.58(2.05)	19.77(1.63)	0.75	0.95
	Blind	17.46(1.09)	17.68(2.53)		
left ear	Sighted	19.66(1.76)	19.53(2.12)	0.91	0.76
	Blind	16.67(2.44)	16.97(2.34)		

*Compared within group, **Compared between group

Table 3. Within and between group comparison of balance, power and body composition in sighted and blind groups

Parameter	Group	Mean (SD)		p*	p**
		Pretest	Post-test		
Dynamic balance	Sighted	1.59(0.53)	2.02(0.72)	0.001	0.15
	Blind	1.03(0.58)	1.61(1.11)		
Statistic balance (S)	Sighted	13.50(2.59)	14.70(3.02)	0.001	0.57
	Blind	14.23(0.62)	15.40(3.50)		
Relative power of the right hand	Sighted	3.94(1.91)	2.83(0.97)	0.001	0.55
	Blind	3.45(2.72)	2.31(1.81)		
Relative power of the left hand	Sighted	3.39(0.83)	3.10(1.38)	0.01	0.90
	Blind	3.88(2.98)	2.42(1.79)		
Leg muscle strength (N/m)	Sighted	16.45(4.59)	18.30(5.53)	0.001	0.23
	Blind	13.60(6.38)	14.70(6.91)		
Body fat percent (%)	Sighted	25.79(6.00)	25.13(6.02)	0.001	0.35
	Blind	28.48(6.97)	27.95(6.85)		

to convey the message to the organs and increases cerebellar carbohydrates. Given that the cerebellum plays a major role in balancing, this kind of exercise can improve further balance.

According to the results of this study, a significant increase in the power of right hand and leg muscle strength in both sighted and blind groups was observed at the end of the period. These results are consistent with the findings of Ismailiyan et al. [23], but it is inconsistent with the findings of Donahoe-Fillmore et al. [24]. It has been confirmed that muscle strength increases as a result of physical exercise [25] and through various physiological mechanisms that are associated with neural agents, skeletal muscle hypertrophy, and hormonal changes [26]. Following the training, there was a significant increase in the strength of the hands and feet of both groups. Regarding the type of exercise, the adaptations of the nervous system in the initial stages of training (up to six weeks) are superior

mechanisms that justify the increase in subjects who did not practice. The mechanism of power increase is due to exercise because of an increase in the number of neural impulses in the motor units, an increase in the size of the muscle mass of type I and II, and an increase in anabolic hormones [27]. Another possible mechanism of increased exercise can be related to muscular neuromuscular adaptation and improvement in the distribution of muscle flow that is because of the physical exercise [28,29].

Based on the results of this study, the percentage of body fat in the two groups of sighted and blind training at the end of the period decreased significantly. Regular physical exercises can reduce body composition and enhance the cardiovascular system. The results of this study indicate the role of selected exercises with an appropriate intensity on weight control and body composition of the subjects. Of course, the type, intensity and duration of selected physical

activity are important variables that can interfere with the type of physical activity [30]. In this regard, various reasons can be mentioned for the difference between the results of this research and other researches. An important reason can be the type of activity because the physiological reason for such a topic is to understand the mechanisms by which the energy required for muscle function is employed. Moreover, according to the recommendations of researchers, volume and time anticipated the aerobic exercise program. It is expected that during this activity, fatty acids will be used as the main fuel by the muscle, thus, reducing body fat. Therefore, considering the aerobic nature of the research, the main factor is its reduction, but the interference of different variables such as nutrition and daily activity of subjects before the beginning of the study can be due to other reasons. Based on the studies, weight loss can be achieved through aerobic exercises, but the intensity or duration of exercise is an important stimulant to reduce body fat [31].

Conclusion

The findings of this study showed that eight weeks of indoor rock climbing workout (IRCW) led to increased dynamic balance, hand strength, and muscle strength of the legs in sighted and congenital blind girls. Therefore, considering the capabilities of blind children and the positive effect of IRCW in the growth of their balance ability, IRCW can be considered as a suitable way to promote the physical fitness of these children.

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Conflict of interest

The authors declared no conflicts of interest.

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