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The Effect of Static Balance Enhance by Table Tennis Training Intervening on Deaf Children

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Abstract**—**Children with hearing impairment have deficits of balance and motors. Although most of parents teach deaf children communication skills in early life, but rarely teach the deficits of balance. The purpose of this study was to investigate whether static balance improved after table tennis training. Table tennis training was provided four times a week for eight weeks to two 12-year-old deaf children. The table tennis training included crossover footwork, sideway attack, backhand block-sideways-flutter forehand attack, and one-on-one tight training. Data were gathered weekly and statistical comparisons were made with a paired *t*-test. We observed that the dominant leg is better than the non-dominant leg in static balance and girl balance ability is better than boy. The final result shows that table tennis training significantly improves the deaf children's static balance performance. It indicates that table tennis training on deaf children helps the static balance ability.

Keywords**—**Deaf children, static balance, table tennis, vestibular structure.

I. Introduction

HEARING loss is usually diagnosed early in life. Research has focused mainly on the development of communication skills and less on motor skills. Shah et al. reported that damaged vestibular structures were accompanied by balance and movement defects in deaf children [1]. Abnormal or delayed postural development is a common sensorimotor impairment in profoundly deaf children and is often associated with vestibular dysfunction [2], [3]. De Kegel et al. showed that 30%–85% of children with severe or profound hearing loss have some degree of vestibular deficit, which interferes with many areas of development, including static and dynamic balance reactions, coordination, and the speed of performed movements [4]. Therefore, most deaf children have a vestibular deficit, which leads to a decline in balance function and inconvenience of life.

Balance is indispensable for the cooperation of athletic performance and physical fitness in daily life. Balance is defined as a person's quick postural adaptation to changes in the center of gravity during rest and activity. It can also be defined as the ability to control the body in both static and dynamic postures with minimal muscular activity [5]. Balance of movements includes balance of the joints in the hips, knees, and ankles. Although balance is considered to be a static process, it is actually dynamic and involves different neural pathways [6]. There are two types of balance—static and dynamic. Static balance is defined as balance when a person is not moving. Dynamic balance is defined as the ability to maintain balance while the body is moving [7].

In the course of exercise and rest, maintaining the body's center of gravity during postural changes is required for normal balance. The development of postural stability involves dynamic interactions between multisensory networks, including the visual, somatosensory, and vestibular systems [8]. Vestibular, sight, and somatic receptors play a very important role in maintaining balance while walking or standing. Children's basic motor skills and balance are inextricably linked. In the basic motor skills such as sitting and feet balance develop more slowly in most deaf children than in children with normal hearing [9]. Lewis et al. reported that participation in a balance and body awareness program improved balance performance in deaf children [10]. Majlesi et al. demonstrated that balance training enhanced somatosensory ability and improved balance in deaf children [11]. These studies suggested that improving visual and somatosensory function during postural control improves motor balance abilities. Sheng et al. showed that three months of table tennis training can improve children's hand movement, balance, and ball skills [12]. Based on the above findings, we hypothesized that table tennis training enhances balance in deaf children.

In this paper, we investigated table tennis training as an approach to balance training in deaf children. Table tennis training emphasizes speed and agility, which requires rapid and flexible stabilization of the body and the ability to balance the orientation and position of the body. Since school-aged children have the best motor skill learning efficiency, we selected 6–12 primary school students as our participants [13]. We observe the balance performance changing of the deaf children to understand the effect of the table tennis training.

The rest of this paper is organized as follows. Section II shows the method and Section III shows the results. Discussions are provided in Section IV, which discusses the effective of improvement of balance after table tennis training. And the conclusion is in Section V.

II. Methods

A. Participants

Two children with hearing loss were recruited from Taipei city. Hearing loss of our participants are both greater than 90 dB, so the cause of deafness is unlimited. Participants were 10 and 12 years old, and had studied table tennis for two years.

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Children with neuro-motor disorders, orthopedic dysfunctions, or medication affecting the central nervous system were excluded. Before the training, all participants were fully informed about the aim and protocol of the study and provided informed consent. The age, height, weight, and degree of hearing impairments are shown in Table I.

TABLE I
CHARACTERISTICS OF THE PARTICIPANTS

	Age (years)	Height (cm)	Weight (g)	Degree of hearing loss
Boy	12	160.9	73900	Profound
Girl	12	154.0	43000	Severe

B. Table Tennis Training

Table tennis training included many exercises aimed at enhancing athletic skills. We selected four training exercises: crossover footwork, sideway attack, back hand block-sideways-flutter forehand attack and one-on-one urgent marking. These training courses aimed to enhance the agility, coordination, and mindfulness of the participants. We hypothesized that these training exercises would improve the balance performance of the participants.

C. Measurement Methods

A pretest-posttest design is utilized in this study to observe the performance of the table tennis training. Before the training course, the pre-test is utilized to measure the participants' balance performance. One leg stance with eyes-closed is our measurement scheme. It means that the participant stands only one leg witheyes-closed. The non-stance foot should be back to 90 degrees. When participant eye opens or non-stance foot puts down, the test is finished. We consider the duration of the single foot stance as the participants' balance performance.

After pre-test, participants are asked to do the each training course 30 seconds for three times. Between each training course, the participants are asked to rest for one minute. When all training courses are finished, the post-test is applied. The post-test is utilized three times and the best one will be gathered. All the pre-test and post-test are utilized four times a week and totally eight weeks.

D. Statistical Analysis

Data were gathered weekly, meaning four tests were averaged as one result. Results were compared using the paired *t*-test. A *p*-value of <0.05 was considered statistically significant.

III. RESULTS

Table II shows the results of the left foot stance with eyes closed test. There was no significant difference in the left foot stance performance of the boy or girl participant after table tennis training. This result indicates that table tennis training has less contribution for static balance.

Table III shows the results of the right foot stance with eyes closed test. The right foot stance performance of both participants improved significantly after table tennis training.

TABLE II
LEFT FOOT STANCE WITH EYES CLOSED

	pre- test	post-test	*t*-test	*p*-value
Boy	1.99	2.14	-1.12	0.15
Girl	3.33	3.81	-1.38	0.11

Note: Values represent the mean.

TABLEIII
RIGHT FOOT STANCE WITH EYES CLOSED

	pre- tests	post-tests	*t*-test	*P*-value
Boy	2.22	2.62	-2.21	0.03*
Girl	3.74	5.30	-2.35	0.02*

Note: Values represent the mean.

We further observe the change in static balance each week. Figs. 1 and 2 show the results of the static balance test for the left and right foot, respectively. Participants in the fourth week of static balance havea clear upward trend.

We further observe the static balance changing for gender. Figs. 3 and 4 show the static balance results for the girl and boy participant, respectively. The dominant leg of both participants was the right leg. In addition, the girl participant showed significantly better improvement in static balance after table tennis training than the boy participant.

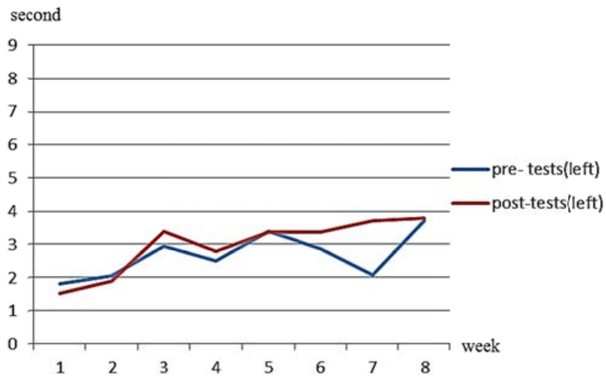

Fig. 1 Mean time of left foot stance with eyes closed

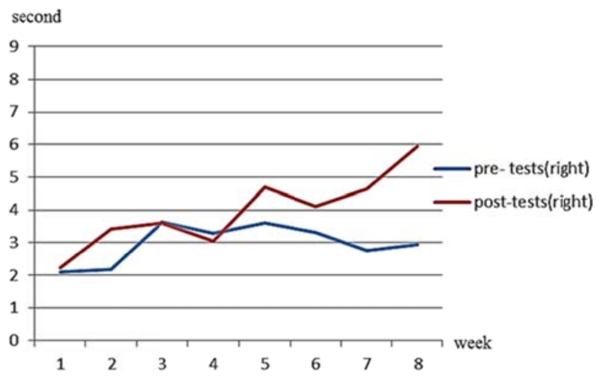

Fig. 2 Mean time of right foot stance with eyes closed

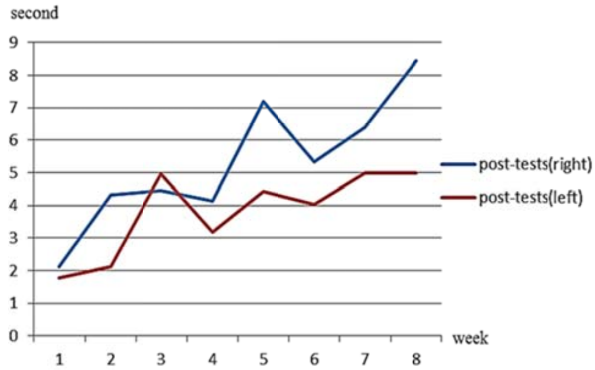

Fig. 3 Static balance of the female participant post-training

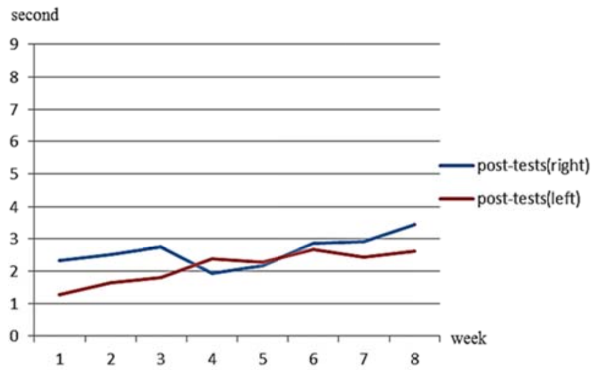

Fig. 4 Static balance of the male participant post-training

In Fig. 5, we compare the static balance test results one week before training (w1) and after eight weeks of training (w8). This comparison can indicate participants' static balance performance changing before table tennis training intervening and after 8 weeks training course. From this figure, we can observe that both left foot and right foot's performance are improved. Especially the right foot, the difference of w1 pre-test and w8 post-test for right foot is significant.

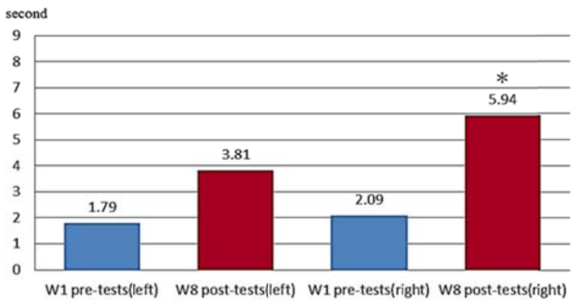

Fig. 5 Static balance test results at week 1 and week 8

IV. Discussion

In this paper, we utilized table tennis training to intervene with static balance ability. Neither participant showed a significant improvement in the left foot stance test after table tennis training. However, both participants improved significantly in the right foot stance test after table tennis training. This indicated that balance performance was enhanced by the training exercises. The results are in agreement with Lewis et al. and Rine et al. researches which improved all participants' balance performance [2], [10]. Rine et al. observed that participation in visual and somatosensory training improved balance performance in deaf children [2], and Lewis et al. found that participation in a balance and body awareness program had a resulted in improved balance performance in deaf children [10]. Our study also supports [11], which showed an improvement in the balance performance of deaf children after participation in proprioception training of balance and gait. In addition, our finding that table tennis training can improve the static balance of deaf children supports the findings of [12] that three months of table tennis training improved deaf children's hand operation, balance, and ball skills.

We found that the balance performance was better on the right foot than the left foot, indicating that the dominant leg has better static balance than the non-dominant leg. This may be because table tennis training is based on the center of gravity of the right foot; therefore, the dominant leg is better. We also observed that the static balance of the female participant improved significantly more than the male participant on both legs, which is similar to the findings of [14], [15]. They used a portable post-urographic digital platform to compare the postural stability of boy and girl and found that girl had better stability than boy. Our findings also demonstrated that school-aged child have the best motor skill learning efficiency. Taiyan et al. and Heng et al. reported that the balance performance of deaf children was two seconds, which is similar to our pre-test [16], [16]. Comparing to Fig. 5, we can obtain that after 8 week table tennis training can improve the static balance performance, in agreement with previous studies.

V. Conclusions

In this study, we focused on table tennis training intervening deaf children's balance training. We found that table tennis training improves static balance in deaf children by increasing the length of time they can stand on one leg with their eyes closed. Our results showed that the dominant leg is better than the non-dominant leg for static balance. In addition, we found that static balance improved significantly more in girl than boy. Finally, we have demonstrated that table tennis training can effectively enhance the static balance of deaf children after eight weeks.

Acknowledgments

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