EFFECTS OF VIBRATION COMBINED WITH UNSTABLE SURFACE TRAINING ON SOMERSAULT ATHLETIC PERFORMANCE OF ARTISTIC GYMNASTS

I-Hsiang Chen[1], Yu-Hsuan Kao[1], Shih-Hang Weng[2], Chen-Fu Huang[1]

Department of Physical Education and Sport Sciences, National Taiwan Normal University[1]
Department of Athletic Performance, National Taiwan Normal University[2]

Purpose: The effect of 4 and 8 weeks of combined training on the somersault performance of artistic gymnasts. **Methods**: 16 male college gymnasts were randomly paired and divided into combined (CT) and vibration (VT) groups for eight weeks of training. One force plate was used to collect the front and back somersault data before, after four, and eight weeks of training. The significance level was set at α = .05. **Results**: Back somersault, the take-off force and somersault height of CT were better than pre-test, and the somersault height was better than VT. Front somersault, the take-off force, impulse, and somersault height of CT are better than pre-test, and the somersault height and take-off force are better than VT. **Conclusion**: The four and eight weeks of vibration combined with unstable surface training can improve the performance of front and back somersaults.

KEYWORDS: front somersault, back somersault, ground reaction force, height, artistic gymnastics

INTRODUCTION: Artistic gymnastics is one of the must-do and popular events in the Asian Games and the Olympic Games. The women's floor, vault, balance beam, and the men's floor and vault all use the lower limbs as the essential movements. The strength and power of the lower limbs determine the success of gymnastics performance. The height, body posture, rotation velocity, and landing stability are important factors for evaluating and scoring standards (International Gymnastics Federation, 2021). Moreover, most gymnastics routines include elements of somersault skills, such as backward, forward, and sideways flips (Weng & Yu, 2012).

Unstable surface training is a method used to improve the balance and control ability of the neuromuscular and proprioceptive system by creating an unstable body state. This can help improve strength coordination, balance control ability, and movement efficiency (Vera-Garcia, Grenier & McGill, 2000; Behm et al., 2005). During unstable surface training, athletes are kept in an unstable control state using a variety of equipment placed on unstable surfaces. Originally used for medical rehabilitation purposes, such as addressing rehabilitation problems after an ankle injury, unstable surface training has since been successfully used in medical treatment to address ankle dysfunction and establish proprioception to help prevent falls in the elderly. As a result, it is now being applied to other populations as well (Akhbari, Takamjani, Salavati, & Sanjari, 2007; Schilling et al., 2009). It has been found that combining unstable surfaces with vibration training can help athletes with chronic ankle instability (CAI). Studies have confirmed that long-term use of unstable surfaces combined with vibration training for more than six weeks can effectively improve the neuromuscular activation of athletes with chronic ankle instability symptoms and significantly enhance the performance of their lower limbs (Cloak et al., 2013; Sierra-Guzmán et al., 2017). Additionally, vibration training has been applied to athletes aged 18-24 in various sports (such as basketball, volleyball, dance, and taekwondo), and studies have verified that its training effect can effectively improve the athletic performance of their lower limbs (Aksoy, 2019; Pérez-Turpin et al., 2014). Some scholars suggest that high vibration frequencies (>30Hz) and high amplitudes (>3mm) with long-term (>10 minutes per session) vibration training can provide sufficient stimulation and overload to effectively enhance explosive power performance (Manimmanakorn, Hamlin, Ross, & Manimmanakorn, 2014). Therefore, the purpose of this study is to investigate the effect of vibration combined with unstable surface training on gymnasts' somersault performance.

METHODS: Sixteen college male artistic gymnasts (age 21.3 ± 1.24 yrs., height 167.63 ± 5.14 cm, weight 60.28 ± 3.32 kg) were randomly assigned and divided into a combined training (CT) and a vibration training group (VT), with eight participants in each group. Both groups were tested for front and back somersaults before training, after four weeks, and after eight weeks. Before the start of the training, participants performed a standardized 10-minute gymnastics warm-up and familiarized themselves with the practice test movements. There was a 10-minute rest between each test, and three successful trials were collected for the front and back somersaults. The best jumping height was used for statistical analysis. For vibration training, the VT group stood on the platform of the vibration training machine (Pro5, Power Plate, USA) in a squat position with knees bent at about 90 degrees and hands on hips, and performed barefoot up-and-down vibration training. The CT group stood on a hardwood balance board (Domyos, Lille, France) on the machine in the same posture as the VT group to train on unstable surfaces simultaneously. Participants performed artistic gymnastics training five times a week, four hours per session. After gymnastics training, the VT and CT groups trained three times a week for eight weeks. Each vibration training session consisted of ten trials, each lasting 60 seconds with a 60-second rest between tests, totalling 20 minutes, as suggested by Manimmanakorn et al. (2014). The intensity was set at high vibration frequency (50Hz) and high vibration amplitude (4mm).

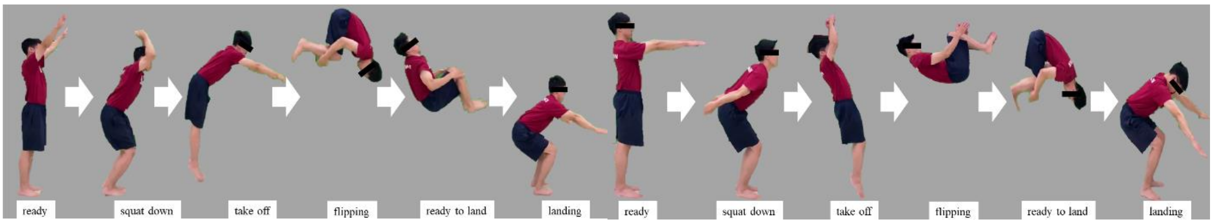

Figure1 detail photos of the front and back somersault

When performing a somersault, the participants stood on the force plate (Kistler 9260AA, Instruments Inc., Winterthur, Switzerland, 2000Hz) and performed front and back somersaults at their best effort. The movement flow is shown in Figure 1; at the beginning, standing on the force plate in a ready position, after performing the movement, when landing, only both feet can land on the floor mat at the same time; the hands must not touch the ground, and no shaking from side to side, walking, jumping or unnecessary arm swinging movements are allowed. If the above situation does not occur, it is a successful test. The peak take-off force (BW), impulse (N·s), take-off time (s), and somersault height (cm) were collected and analyzed by using BioWare software to collect and analyse. Vertical ground reaction force (VGRF) curve maximum and impulse during somersault take-off. The maximum value will be divided by the subject's weight for normalization and will represent the take-off force. After the take-off period, when the VGRF curve is lower than 20 N, it is defined as the moment when both feet leave the ground, and when the VGRF curve exceeds 20 N, it is the moment when both feet touch the ground. The time from when the feet leave the ground to when the feet touch the ground is the take-off time. The formula = $1/2*g*(t/2)^2$ to convert take-off time to somersault height (Byrne & Eston, 2002). The parameters were analyzed using SPSS 22.0 mixed two-way ANOVA to test the differences in the dependent variables between the two groups of participants. When the interaction is significant, the simple main effect test analysis is carried out, and the LSD method is used for postdoc comparison processing; if the interaction is not significant, the main effect test analysis is carried out. Data are presented as mean ± standard deviation, and the significance level is $p \leq 0.05$.

RESULTS: For the results of the front somersault, table 1 showed that the peak take-off force of the CT group was significantly better than the VT group after eight weeks (p = .046). And the somersault height was significantly higher than the VT group after four weeks and eight weeks of training (p = .013). In addition, the peak take-off force, take-off impulse, and somersault height of the CT group were significantly better than those of the pre-test after 4 and 8 weeks of training (force: p = .002; impulse: p = .001; height: p = .001). For the back somersault, the peak take-off force and somersault height of the CT was significantly better than those of the pre-test after 4 and 8 weeks of training (force: p = .001; height: p = .001). Also, the somersault height of the CT group was significantly better than the VT group after four weeks and eight weeks of training (p = .001).

Table1: Analysis of Dynamic Result in Somersault Take-off Period.

project	Dependent	group	pre	4wks	8wks
front somersault	take-off force (BW)	CT	5.54 ± 0.30	5.94 ± 0.45 *	6.13 ± 1.02 *†
		VT	5.28 ± 1.07	5.21 ± 0.82	5.17 ± 0.64
	impulse (N·s)	CT	521.88 ± 119.12	599.91 ± 97.19*	585.29 ± 101.00*
		VT	506.87 ± 77.76	502.91 ± 111.78	500.62 ± 81.68
	take-off time (s)	CT	0.60 ± 0.15	0.64 ± 0.28	0.72 ± 0.10
		VT	0.59 ± 0.08	0.58 ± 0.13	0.59 ± 0.07
	height (cm)	CT	29.97 ± 2.85	33.60 ± 1.61 *†	33.89 ± 1.64 *†
		VT	29.03 ± 1.94	29.57 ± 2.45	29.27 ± 2.34
back somersault	take-off force (BW)	CT	2.93 ± 0.35	3.12 ± 0.42*	3.43 ± 0.34*
		VT	2.95 ± 0.41	3.00 ± 0.48	3.03 ± 0.43
	impulse (N·s)	CT	748.11 ± 157.89	790.74 ± 92.00	800.22 ± 127.37
		VT	791.30 ± 173.49	792.31 ± 113.73	775.77 ± 99.11
	Take-off time (s)	CT	0.88 ± 0.16	0.95 ± 0.06	0.97 ± 0.10
		VT	0.91 ± 0.17	0.94 ± 0.07	0.91 ± 0.06
	height (cm)	CT	41.74 ± 4.19	47.05 ± 2.36 *†	47.91 ± 2.30 *†
		VT	41.87 ± 4.06	41.79 ± 3.46	41.05 ± 3.78

*Note: * indicates a significant difference with the pretest; † indicates a significant difference between the two groups.*

DISCUSSION: This study is the first to examine the effect of unstable surface combined with vibration training on somersault performance in gymnasts. After four and eight weeks of this training, it was found that gymnasts' performance in front and back somersaults significantly improved. However, no differences were found in take-off peak force, impulse, take-off time, and jumping height for front and back somersaults after four and eight weeks of VT training, indicating that VT training did not enhance the gymnasts' lower body explosive power during these movements. In a previous study, 33 male football players with chronic ankle instability (CAI) were recruited to participate in a 6-week vibration and unstable surface training program to improve CAI symptoms and athletic performance. The participants' lower limb balance power and explosive performance were measured using a one-foot static balance test, star excursion balance test, and single-leg triple jump explosive power test before and after the training. The results showed that vibration and unstable surface training substantially enhanced lower limb balance power and improved CAI symptoms (Cloak, Nevill, Day, & Wyon, 2013). In another study by Sierra-Guzmán et al. (2017), 50 athletes with CAI were recruited to participate in a 6-week combined training program of vibration and unstable surfaces. The study found that the training improved the subjects' pretibial muscle activation of the calf muscle, medial gastrocnemius, and lateral gastrocnemius, reducing the risk of recurrence of ankle sprains. However, it did not improve isokinetic muscle strength of the calf. The authors suggested that the lack of improvement in calf muscle strength might be due to the use of a BOSU ball placed on a vibrating platform, which weakened the training intensity generated by the vibration machine due to the ball's soft surface. Future research could focus on the effects of hard and soft unstable surfaces on combined training.

CONCLUSION: This study found that after four weeks and eight weeks of unstable surface combined with vibration training, the performance of gymnasts' front somersault and back somersault was significantly improved. However, it also found that no difference was observed in take-off peak force, impulse, take-off time, and jumping height of front and back somersault after four weeks and eight weeks of VT training. Therefore, it can be concluded that VT training did not enhance the performance of gymnasts' lower body explosive power on front and back somersault movements.

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