EJSSE

Eurasian Journal of Sport Sciences and Education
Avrasya Spor Bilimleri ve Eğitim Dergisi
Vol: 5, Issue: 2, 2023
E-ISSN: 2717-8455
URL: http://www.dergipark.org.tr/ejsse

The Effects of Acute Vibration with Exercises Applied to the Lower Extremities on Balance Performance

Mehmet Şerif ÖKMEN[1†1], **Emre ŞİMŞEK**[2]
[1]Mardin Artuklu University, Mardin, Türkiye
[2]Erciyes University, Kayseri, Türkiye

Original Article **DOI: 10.47778/ejsse.1340346**
Received: 09.08.2023 Accepted: 10.09.2023 Online Published: 30.09.2023

Abstract

This study was conducted to investigate the effects of exercises with acute vibration applied to the lower extremities on balance performance. The study included 68 voluntary participants, consisting of 34 male and 34 female athletes specializing in different branches who were students at the Faculty of Sport Sciences at Erciyes University. The participants were randomly divided into three groups, and different protocols were applied in each group. These groups were the exercise (E) group, the vibration + exercise (VE) group, and the control (C) group. Dynamic squats, standing calf raises (static surface), and right and left lunge exercises were performed for 30 s in the E and VE group, while no intervention was made in the C group during the same time. The VE group performed the exercises on the DKN XG10 vibration platform with vibration at 30 Hz, while the E group performed the same exercises on the same platform without vibration. The static and dynamic balance performance levels of the participants were measured using the Biodex Balance System (BBS) before and after the protocols, and the results were statistically compared. In the intragroup comparisons, there were significant differences between the pretest and posttest static balance parameters of the E group regarding their OSI and APSI values ($p<0.05$). Moreover, in terms of dynamic balance parameters, the OSI and MLSI results ($p<0.01$) of the VE group and the OSI ($p<0.01$), APSI ($p<0.01$), and MLSI results ($p<0.05$) of the E group varied significantly between the pretest and the posttest. In further studies, it is recommended to investigate the effects of different exercise types, acute vibration applied at different frequencies or durations on balance performance.

Keywords: Balance, Exercise, Vibration

Alt Ekstremiteye Uygulanan Akut Titreşim Egzersizlerinin Denge Performansına Etkisinin İncelenmesi

Öz

Bu araştırma, alt ekstremiteye akut titreşim ile birlikte uygulanan egzersizlerin denge performansına etkisini incelemek amacıyla yapılmıştır. Çalışmaya Erciyes Üniversitesi Spor Bilimleri Fakültesinde öğrenim gören farklı branşlarda uzmanlaşmış 34 kadın, 34 erkek olmak üzere toplam 68 sporcu gönüllü olarak katılmıştır. Çalışmaya katılan gönüllüler randomize olarak üç farklı gruba ayrılmış ve her gruba farklı protokoller uygulanmıştır. Bu gruplar, egzersiz (E) grubu, titreşim + egzersiz (VE) grubu ve kontrol (C) grubu olarak belirlenmiştir. E ve VE gruplarına dinamik squat, standing calf raises (sabit), sağ ve sol lunge egzersizleri 30 sn boyunca uygulanmış, K grubuna ise aynı süre içerisinde herhangi bir uygulama yapılmamıştır. VE grubu egzersizleri DKN XG10 titreşim cihazında 30 Hz'de titreşim uygulamalarıyla, E grubu ise aynı cihaz üzerinde titreşim uygulaması olmadan yapmıştır. Uygulanan bu protokol öncesi ve sonrası gönüllülerin statik ve dinamik denge performansları Biodex Denge Sistemi (BBS) ile belirlenerek istatistiksel karşılaştırmaları yapılmıştır. Grup içi ön test ve son test statik denge verilerinde E grubunun OSI ve APSI değerleri arasında anlamlı farklılık olduğu ($p<0,05$), dinamik dengede ise VE grubunun OSI ile MLSI değerlerinde ($p<0,01$), E grubundaysa OSI ($p<0,01$), APSI ($p<0,01$) ve MLSI ($p<0,05$) değerinde anlamlı farklılık olduğu tespit edilmiştir. Sonuç olarak, akut titreşim ile uygulanan egzersizlerin statik dengeyi kliniksel açıdan iyileştirdiği ancak anlamlı farklılık oluşturmadığı, dinamik dengeyi ise anlamlı derecede iyileştirdiği söylenebilir. İleri araştırmalarda farklı egzersiz türleri, farklı frekans veya sürelerde uygulanan akut titreşimin denge performansına etkilerinin araştırılması önerilmektedir.

Anahtar kelimeler: Denge, Egzersiz, Titreşim

---

† **Corresponding Author:** Mehmet Şerif Ökmen, **E-mail:** mserifokmen@gmail.com

INTRODUCTION

Vibration is defined as mechanical oscillations that occur because of periodic changes in the initial position of an object by regular or irregular motions (Cardinale and Bosco, 2003). During our activities of daily living, we are exposed to mechanical vibrations coming from the external environment, and these vibrations may help our body perform metabolic functions efficiently (Cardinale and Wakeling, 2005; Chan et al., 2013). It has been assumed that the low-amplitude high-frequency stimulation (vibration) of the entire body has favorable effects on many risk factors regarding falls and associated fractures by simultaneously improving muscle strength, body balance, and the mechanical competence of bones (Hibino et al., 2023). In general, during all controlled body vibration cases, when the individual is on a vibration platform, they are exposed to two main vibration effects, namely horizontal alternating (oscillating) and vertical (linear) effects (Rittweger, 2010). The transmission of such mechanical vibrations to the human body causes the tonic vibration reflex, which is a complicated spinal and supraspinal neurophysiological response (Rittweger, 2010; Zaidell et al., 2013). The tonic vibration reflex increases muscle activation and improves functional performance (Bogaerts et al., 2007; Stolzenberg et al., 2013; Huang and Pang, 2019). Because they have short- and long-term effects, vibration exercises have recently been utilized in several sports branches to improve various motor characteristics and different performance parameters (Şengür et al., 2018). One of the motor characteristics that play an effective role in daily life and success in sports is balance.

Balance refers to the ability of the person to keep their center of gravity and base of support on the same plane and maintain this situation (Gür and Ersöz, 2017). Balance is controlled by a complex and multifaceted neuromuscular process that constantly produces the responses necessary to maintain balance and involves afferent and efferent systems (Winter, 1995). The control mechanisms of balance include the integration of sensations coming from visual, vestibular, and position sense (proprioception) systems, motor functions, and cognitive functions (Howe et al., 2007). These complex connections in balance are also categorized in two different ways depending on whether the individual is in balance and whether the surface is static or dynamic (Muratlı, 2003; Spirduso, 1995; Şimşek et al., 2020). In the context of data obtained using novel technological devices that are used in laboratory settings in the current literature, balance is also expressed in the form of position changes in the body's center of gravity as Anterior-Posterior (A-P) and Medial-Lateral (M-L) balance (Şimşek and Arslan, 2019).

Previous studies have shown that whole-body vibrations provide acute or chronic adaptations and have positive effects on qualities such as strength (Rønnestad et al., 2004; Turner et al., 2011), speed (Mc Bride et al., 2009), throwing speed in handball (Şimşek and Ünver, 2020), and balance (Dallas et al., 2014; Despina et al., 2014; Cloak et al., 2016; Fort et al., 2012; Ritzmann et al., 2014). When the effects of acute vibration on balance performance are examined in the literature, there are studies reporting positive effects on volleyball players (Usta-Demir, 2009), football players (Berk et al., 2021; Cloak et al., 2014), rhythmic gymnasts (Despina et al., 2014) and dancers (Karim et al., 2019). There are also studies reporting that acute vibration applications do not have any effect on balance performance (Mahbub et al., 2020; Kaçoğlu, 2019; Pollock et al., 2011). However, it is seen that there is still insufficient information about the short- and long-term effects of whole-body vibration exercises on static or dynamic balance (Hibino et al., 2023). In addition to this, it is seen that there is a dearth of studies in the literature in which the acute effects of whole-body vibration on balance are investigated using validated, reliable, fast, and clinically reproducible tests (Karim et al., 2019). Therefore, considering these issues in the literature, this study was conducted to investigate the effects of exercises applied to the lower extremities along with acute vibration on static and dynamic balance.

METHOD

Study Design

This study was planned with an experimental design, which is a quantitative research design. The design of the study included a pretest, a posttest, and a control group.

Research Group

The sample of the study included 68 voluntary participants, consisting of 34 male and 34 female athletes specializing in different branches (Athletic, Basketball, Fencing, Football, Wrestling, Weightlifting, Karate, Kickbox, Table Tennis, Muay Thai, Taekwondo, Tennis, Volleyball, Bodybuilding, Swimming) who were students at the Faculty of Sport Sciences at Erciyes University. The criteria for inclusion of volunteers in the study; must be specialized in a sports branch, BMI values must not be in the obese class (30 kg/m^2 and above), and must not have any disability (orthopedic injuries, etc.) that will prevent them from participating in the study. They were randomly divided into three groups, which were the exercise (E), vibration + exercise (VE), and control (C) groups.

Data Collection Instruments

Height and Weight Measurements: The height of each participant was measured barefooted at a precision of 0.1 cm using a standard steel stadiometer, while their weight (BW) was measured barefooted and with shorts and a t-shirt on at a precision of 0.1 kg using a scale. The BMI values of the participants were calculated in kg/m2 using their weight and height measurements.

Balance Measurements: In this study, the Biodex Balance System (Biodex, Inc, Shirley, New York) was used to make balance measurements. BBS has mobility levels in the range of 1-12, and the 1st level corresponds to the greatest degree of mobility. The balance score obtained with BBS shows a better preservation of posture when it approaches 0 and a poorer preservation of posture when it diverges from 0.

Both static and dynamic balance measurements were made in this study. While the dynamic balance measurements were made on the 1st-level mobile platform, the static balance measurements were made on the stationary platform. Before the measurements, the participants were allowed to try the platform for a short time. The participants were instructed to stay still and not speak during the measurements, and both types of balance measurements were made barefoot.

The arms of the participants were relaxed and down for the static balance measurements and fixed at their chest in a crossed position for the dynamic balance (1st level) measurements. The measurements were taken for 30 s, the tests of the participants who either lost their balance completely or hung on to the platform for support were ended, and their measurements were repeated (Şimşek and Arslan, 2019; Şimşek et al., 2020). Three different parameters were determined (OSI: Overall Stability Index, APSI: Anterior-Posterior Stability Index, MLSI: Medial-Lateral Stability Index), and the results were statistically compared.

Vibration Interventions: The interventions involving vibration were applied using the DKN XG10 vibration platform that can produce vibrations at different frequencies and for different durations. The interventions were made for 30 s at a frequency of 30 Hz. Before starting the protocol, all exercises were visually introduced to the athletes, and the athletes were allowed to try them once after informing them about the implementation criteria. Four different exercises were performed with rest breaks of 30 s between exercises. These exercises were as follows:

1. Dynamic Squat
2. Standing Calf Raises (Stand on Toes and Wait)
3. Lunge (Right Foot)
4. Lunge (Left Foot)

Ethical Approval

All participants were informed about the research procedure, the inclusion criteria, the potential problems they could encounter, and the requirements of the process. They were informed that they could withdraw from the study at any time, and they signed an informed consent form before their participation. The study protocol was implemented in accordance with the principles of the Declaration of Helsinki, and it was approved by the Non-Invasive Clinical Studies Ethics Committee of Erciyes University with the decision dated 03.05.2023 and numbered 2023/5-9. The measurements were made in the Laboratory of the Faculty of Sport Sciences at Erciyes University.

Data Collection

For the participants who were randomly divided into 3 groups, the research protocol consisted of the stages of warm-up, pretest, exercises (with (VE) and without (E) vibration) or rest (C), and posttest. While the participants in C did not participate in any intervention, those in E performed exercises without vibration for 30 s, and those in VE performed exercises with vibration for 30 s.

1. *Dynamic Squat:* The Hawkey and Dallaway (2020) protocol was followed for dynamic squat exercises. The participants performed a dynamic squat movement by moving down in 2 s and up in 2 s at knee angles changing in the order of 25°, 80°, and 25° when the soles of both feet were completely in contact with the vibration platform.
2. *Standing Calf Raises (Stand on Toes and Wait):* The participants performed the exercises at a fixed position while their knees were slightly bent, and their trunk was in an upright position as they rose on their toes and waited.

3. *Lunge Position (Right Foot):* The participants performed the exercise at a fixed position as their right knee was bent 90°, the sole of their right foot was completely in contact with the platform, and their left foot was on the floor.
4. *Lunge Position (Left Foot):* The participants performed the exercise at a fixed position as their left knee was bent 90°, the sole of their left foot was completely in contact with the platform, and their right foot was on the floor.

Before the pretest balance measurements, the participants performed an active warm-up for 10 min, and the pretest measurements were made immediately after the warm-up. After the pretest, the participants in E performed the exercises described above, while those in VE performed the same exercises along with vibration. The participants in C were allowed to rest for as long as it took for the participants in the other groups to complete their exercises. Torvinen et al., (2002b) reported that the positive effects of acute whole-body vibrations are observed 2 min after the intervention, but they disappear almost completely after 1 h. Thus, in this study, a 2-min break was allowed after the intervention protocol, and the procedure was completed by making posttest balance measurements right after the break.

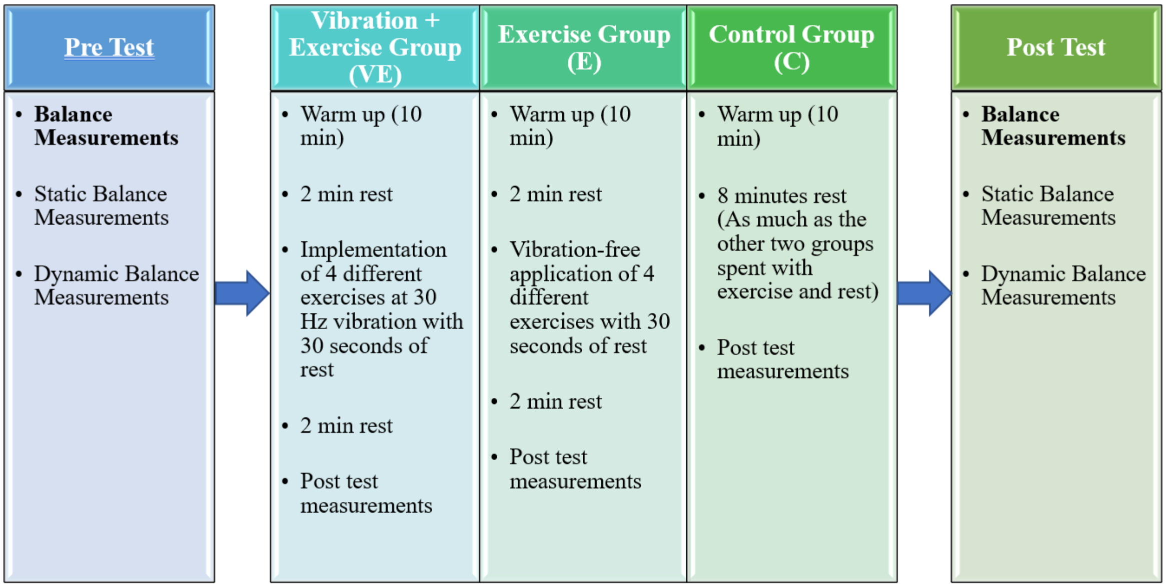

Figure 1. Scheme of the protocol applied in the study.

Data Analysis

The data that were collected in the study were analyzed using the SPSS 22 package program. Normal distribution assumptions were tested using the Kolmogorov-Smirnov test, skewness-kurtosis values, and histogram plots. Parametric tests were used for the normally distributed data, and non-parametric tests were used for the non-normally distributed data. Intergroup comparisons for the normally distributed data were made using one-way ANOVA and post hoc Tukey's HSD tests. For the non-normally distributed data, intragroup comparisons were made using the Wilcoxon test, intergroup comparisons were made using the Kruskal-Wallis H test, and pairwise comparisons were made using the Mann-Whitney U test.

FINDINGS

Table 1. Demographic information

Variable	Group	n	X	SD	Statistics	P Value and Differences
Age (year)	VE	26	21,35	,85	X^2 = 7,019	**,030* C – E, VE**
	E	22	21,05	,79		
	C	20	22,30	1,92		
Height (cm)	VE	26	171,96	7,33	F= 1,343 Df= 2	,268
	E	22	173,52	9,37		
	C	20	169,30	8,61		
BW (kg)	VE	26	69,03	12,55	F= ,104 Df= 2	,902
	E	22	68,58	13,94		
	C	20	67,22	14,72		
BMI (kg/m^2)	VE	26	23,24	3,26	F= ,276 Df= 2	,760
	E	22	22,61	3,25		
	C	20	23,24	3,26		
Sport Age (Year)	VE	26	7,15	4,63	X^2 = 2,046	,360
	E	22	6,27	5,43		
	C	20	8,60	4,49		

*** p<0,05 | VE:** Vibration + Exercise Group, **E:** Exercise Group, **C:** Control Group.

Table 1 shows statistical comparisons with the mean and standard deviation values of the participant's age, height, BW, BMI, and sports age variables. When the data were analyzed, a statistically significant difference was found between VE (*M*= 21.35, *SD*= .85), E (*M*= 21.05, *SD*= .79), and C (*M*= 22.30, *SD*= 1.92) groups in the age variable (p<0.05). It was determined that this difference was in favor of the C group with the E and VE groups. No significant difference was found between the groups in other variables (p>0.05).

Table 2. Intragroup and intergroup comparisons of mean and standard deviation values of static balance measurements

Static Balance Variables	**Group**	**VE** (n=26) X ± SD	**E** (n=22) X± SD	**C** (n=20) X ± SD	**Kruskal Wallis H**		**Significant Differences**
					X^2	**p**	
OSI	Pre-Test	,52 ± ,39	,57 ± ,32	,34 ± ,18	8,459	**,015***	**C – VE, E**
	Post-Test	,46 ± ,23	,41 ± ,33	,37 ± ,16	2,695	,260	
	Z	-,792	-2,263	-,986			
	P	,428	**,024***	,324			
APSI	Pre-Test	,37 ± ,21	,45 ± ,31	,26 ± ,13	6,083	**,048***	**C – VE, E**
	Post-Test	,35 ± ,19	,30 ± ,27	,23 ± ,10	5,886	,053	
	Z	-,729	-2,296	-,761			
	P	,466	**,022***	,447			
MLSI	Pre-Test	,25 ± ,33	,21 ± ,16	,17 ± ,11	2,681	,262	
	Post-Test	,21 ± ,15	,20 ± ,20	,20 ± ,12	,619	,734	
	Z	-,519	-,233	-1,069			
	p	,604	,816	,285			

*** p<0,05 | VE:** Vibration + Exercise group, **E:** Exercise group, **C:** Control group. When the data is examined in the row, comparison between TE, E and C groups, and when analyzed in the column, within-group comparison results are given.

Table 2 shows the statistical comparisons of VE, E and C groups with the mean and standard deviation values of the pre-test and post-test static balance (OSI, APSI and MLSI) parameters. According to the findings, a significant difference was found between the pre-test static balance values of the OSI [VE (*M*= .52 *SD*= .39), E (*M*= .57, *SD* = .32) and C (*M*= .34, *SD*= .18)] and APSI [VE (*M*= .37, *SD*= .21), E (*M*= .45, *SD* = .31) and C (*M*= .26, *SD*= .13)] balance parameters in the comparisons between the groups (p<0.05). It was determined that this difference was in favor of the C group with the E and VE groups. When the in-group comparisons were examined, a significant difference was found between the pre-test OSI (*M*= .57, *SD*= .32) and post-test OSI (*M*= .41, *SD*= .33), and the pre-test APSI (*M*= .45, *SD*= .31) and post-test APSI (*M*= .30, *SD*= .27) balance values of the E group in favor of the posttest (p<0.05). There was no significant difference between the other balance parameters, both within the group and between the groups (p>0.05).

Table 3. Intragroup and intergroup comparisons of mean and standard deviation values of dynamic balance measurements

Dynamic Balance Variables	**Group**	**VE** (n=26) X ± SD	**E** (n=22) X± SD	**C** (n=20) X ± SD	**Kruskal Wallis H**	
					X^2	**p**
OSI	Pre-Test	5,31 ± 3,75	6,66 ± 4,69	5,24 ± 4,04	1,463	,481
	Post-Test	3,95 ± 3,81	4,90 ± 4,15	4,90 ± 3,71	,978	,613
	Z	-2,975	-3,442	-1,308		
	P	**,003****	**,001****	,191		
APSI	Pre-Test	3,45 ± 2,62	4,40 ± 3,55	3,57 ± 2,53	,637	,727
	Post-Test	3,07 ± 3,15	3,20 ± 2,64	3,43 ± 2,60	,771	,680
	Z	-1,494	-3,203	-,673		
	P	,135	**,001****	,501		
MLSI	Pre-Test	3,20 ± 2,40	3,43 ± 2,61	3,09 ± 2,83	,345	,842
	Post-Test	2,27 ± 1,93	3,06 ± 2,84	2,77 ± 2,30	,540	,763
	Z	-2,990	-2,558	-1,876		
	p	**,003****	**,011***	,061		

*** p<0,05, ** p<0,01** | **VE:** Vibration + Exercise group, **E:** Exercise group, **C:** Control group. When the data is examined in the row, comparison between TE, E and C groups, and when analyzed in the column, within-group comparison results are given.

Table 3 shows statistical comparisons with the mean and standard deviation values of the pre-test and post-test dynamic balance (OSI, APSI and MLSI) parameters of VE, E and C groups. According to the findings, a significant difference was found between the OSI [Pre (*M*= 5.31, *SD*= 3.75), Post (*M*= 3.95, *SD*= 3.81)] and MLSI [Pre (*M*= 3.20, *SD*= 2.40), Post (*M*= 2.27, *SD*= 1.93)] dynamic balance values of the VE group, and the OSI [Pre (*M*= 6.66, *SD*= 4.69), Post (*M*= 4.90, *SD*= 4.15)], APSI [Pre (*M*= 4.40, *SD*= 3.55), Post (*M*= 3.20, *SD*= 2.64)] and MLSI* [Pre (*M*= 3.43, *SD*= 2.61), Post (*M*= 3.06, *SD*= 2.84)] dynamic balance values of the E group (p<0.01, *p<0.05). There was no significant difference between the other balance parameters, both within the group and between the groups (p>0.05).

DISCUSSION and CONCLUSION

This study was conducted to investigate the effects of exercises with acute vibration applied to the lower extremities on static and dynamic balance performance. In the intragroup (pretest/posttest) comparisons, while there were statistically significant differences in the static OSI and APSI values of the E group, there was no significant difference in the VE and C groups. In the intergroup comparisons, there were significant differences in the pretest static OSI and APSI values of the groups, where the values of the C group were better than those of the E and VE groups. There was no significant difference in other static balance parameters. In the intragroup comparisons of the dynamic balance values, the dynamic OSI and MLSI values of the VE group and OSI, APSI, and MLSI values of the E group were determined to significantly improve. On the other hand, there was no significant change in these parameters in the C group. No significant difference was determined in the intergroup comparisons.

Whole-body vibration is defined as the transfer of mechanical oscillations to the body through a vibration platform (Tomas et al., 2011; Cited in Şimşek and Ünver, 2020). The greatest advantage of vibration exercises is that they increase the number of sarcomeres that facilitate the contraction of the muscle based on the increased activation of muscle spindles by the stimulation of multiple muscle fibers in a very short time. Therefore, they induce involuntary contractions in the muscle, and these contractions increase gradually and stay on a fixed level until the vibration application ends (Latash, 1998; Cited in Şimşek and Ünver, 2020). This way, for an activity that is performed right after whole-body vibration exposure, the stimulated sarcomeres can be facilitated to contribute more to contractions. This, in turn, is expected to have a net effect on performance outcomes.

Among studies in the literature performed with acute vibration exercises, Berk et al., (2021) reported that the acute vibration exercises applied to the lower extremities of football players affected static and dynamic balance values positively. Usta-Demir (2019) stated that the acute whole-body vibration exercise performed by volleyball players in their study did not show a significant change in static forward-backward swing, right-left swing, forward-backward and right-left swing velocities, or swing area, while there was a significant difference only in the dynamic average track error. In their study where the effects of acute whole-body vibration exercises in elite and amateur male football players, Cloak et al., (2014) found that the elite players responded positively to vibration stimuli and showed significant improvements in dynamic postural stability index (DPSI) values, but the exercises did not have the same effect in the amateur players. Despina et al., (2014) compared the effects of 5 different acute vibration interventions after 15 min in a group of rhythmic gymnasts and determined a significant difference in forward-backward dynamic balance values in favor of those who took part in the vibration interventions. Torvinen et al., (2002b) reported that acute whole-body vibrations had a significant positive effect on lower extremity muscle performance and postural balance in young adults. The same authors stated that these effects were observed 2 min after the intervention, but they almost completely disappeared after 1 h. Karim et al., (2019) argued that whole-body vibration exercises are worth considering as a fast method in the improvement of static balance among dancers. Schlee et al., (2012) observed that acute whole-body vibration training performed by healthy young volunteers reduced plantar foot sensitivity but led to improvements in balance and movement control. In their meta-analysis, Yin et al., (2023) revealed that whole-body vibration exercises had a positive effect on balance and gait functions in paralyzed patients. In our study, while the acute vibration intervention created quantitative improvements in both static and dynamic balance parameters, only some dynamic balance parameters (OSI and MLSI) showed statistically significant improvements. The acute effect of vibration exercises is likely to be mediated by neuromuscular and neural reactions. The general increase in neuromuscular activation as a response to whole-body vibration causes the acutely increased coactivation of lower extremity extensor and flexor muscles (Pollock et al., 2010; Roelants, 2004). Additionally, it may be suggested that acute vibration improves muscle performance through neurogenic potentiation involving spinal reflexes and muscle activation (Marin et al., 2021; Tsai et al., 2021), and performance in some balance parameters increases in line with this effect.

Furthermore, in the relevant literature, there are also studies that have reported no significant effect of acute vibration exercises on balance performance (Hibino et al., 2023; Kaçoğlu, 2019; Mahbub et al., 2020; Pollock et al., 2011; Torvinen et al., 2002a). In our study, as well, while there was a quantitative increase in the values of static balance parameters, the acute vibration intervention did not create a statistically significant improvement. Accordingly, it can be stated that acute vibration interventions do not influence static balance performance. On the other hand, as stated above, the dynamic balance values of the participants of our study were affected positively by the acute vibration exercises. It is believed that these highly variable results in different studies in the literature, including ours, may be related to differences in the methods used or the samples included in these studies. Moreover, these differences may have also been caused by the tonic vibration reflex. The tonic vibration reflex is affected by four factors: (1) the region of vibration, (2) the stimulability of the central nervous system, (3) muscle length before contraction, and (4) the frequency and amplitude of vibration (Bishop, 1974, Cited in Şimşek and Kırkaya, 2021). It was also shown that vibration had both facilitating and suppressing effects on muscle spindle activity, and both of these effects caused altered motor outputs (Pope and DeFreitas, 2015). Some studies demonstrated that acute whole-body vibration interventions led to an increase in the activation of leg muscles, and they caused changes in maximal voluntary contraction values at rates varying between 12.6% and 82.4% (Roelants et al., 2006). Maximum strength improvements of 10.4% and 7.9% in elite and amateur athletes, respectively, were attributed to stimulation by vibrations. As opposed to this, a 65-Hz vibration stimulus applied directly to the biceps tendon reduced neuromuscular performance (Moran et al., 2007). As clearly seen in these results, research outputs can be substantially influenced by the samples that are included in different studies, as well as different research methods.

According to the results of this study, considering the static balance parameters (pretest/posttest), the balance performance values of the VE and E groups improved clinically, but there was a statistically significant difference only in the E group. In contrast, in the C group, there were clinical declines in two parameters (OSI and MLSI), although this deterioration was not statistically significant. In this case, it can be suggested that rather than waiting and not performing any exercise or performing exercises along with vibration input, performing exercises alone (without vibrations) can significantly improve static balance performance. In terms of the dynamic balance parameters, it can be considered that dynamic balance can be improved by exercising with or without the inclusion of vibration interventions. Hence, it was concluded that exercises applied along with acute vibration clinically improve static balance, while the rate of this improvement is not statistically significant, and they improve dynamic balance significantly. For future studies, investigating different types of exercises by the inclusion of different frequencies of vibrations applied for different durations can be recommended.

Conflict of İnterest: The authors do not have any personal or financial conflicts of interest within the scope of the study.

Researchers' Contribution Rate Statement: Research Design-MŞÖ; EŞ, Statistical Analysis-EŞ, Preparation of The Article- MŞÖ; EŞ.

Ethical Approval
Committee Name: Non-Invasive Clinical Studies Ethics Committee of Erciyes University
Date: 03.05.2023
Number: 2023/5-9

REFERENCES

Berk, Y., Polat, Y., ve Marangoz, İ. (2021). *Futbolcularda alt ekstremiteye uygulanan akut vibrasyon antrenmanının denge ve hız üzerine etkisi*. LAP Lambert Academic Publishing.

Bishop, B. (1974). Vibratory Stimulation: Part I. Neurophysiology of motor responses evoked by vibratory stimulation. *Physical Therapy, 54*(12), 1273-1282. https://doi.org/10.1093/ptj/55.2.139

Bogaerts, A., Verschueren, S., Delecluse, C., Claessens, A. L., & Boonen, S. (2007). Effects of whole body vibration training on postural control in older individuals: A 1 year randomized controlled trial. *Gait Posture, 26*, 309-316. https://doi.org/10.1016/j.gaitpost.2006.09.078

Cardinale, M., & Bosco, C. (2003). The use of vibration as an exercise intervention. *Exercise and Sport Sciences Reviews, 31*(1), 3-7. https://doi.org/10.1097/00003677-200301000-00002

Cardinale, M., & Wakeling, J. (2005). Whole body vibration exercise: Are vibrations good for you? *British Journal of Sports Medicine, 39*(9), 585-589. https://doi.org/10.1136/bjsm.2005.016857

Chan, M.E., Uzer, G., & Rubin, C. T. (2013). The potential benefits and inherent risks of vibration as a non-drug therapy for the prevention and treatment of osteoporosis. *Current Osteoporosis Reports, 11*(1), 36-44. https://doi.org/10.1007/s11914-012-0132-1

Cloak, R., Nevill, A., & Wyon, M. (2014). The acute effects of vibration training on balance and stability amongst soccer players. *European Journal of Sport Science, 16*(1), 20-26. https://doi.org/10.1080/17461391.2014.973912

Dallas, G., Kirialanis, P., & Mellos, V. (2014). The acute effect of whole body vibration training on flexibility and explosive strength of young gymnasts. *Biology of Sport, 31*(3), 233. https://doi.org/10.5604/20831862.1111852

Despina, T., George, D., George, T., Sotiris, P., George, K., Maria, R., & Stavros, K. (2014). Short-term effect of whole-body vibration training on balance, flexibility and lower limb explosive strength in elite rhythmic gymnasts. *Human Movement Science, 33*, 149-158. https://doi.org/10.1016/j.humov.2013.07.023

Fort, A., Romero, D., Bagur, C., & Guerra., M. (2012). Effects of wholebody vibration training on explosive strength and postural control in young female athletes. *The Journal of Strength Conditioning Research, 26*(4), 926-936. https://doi.org/10.1519/JSC.0b013e31822e02a5

Gür, F., ve Ersöz, G. (2017). Kor antrenmanın 8-14 yaş grubu tenis sporcularının kor kuvveti, statik ve dinamik denge özellikleri üzerindeki etkisinin değerlendirilmesi. *Spormetre, 15*(3), 129-138. https://doi.org/10.1501/Sporm_0000000317

Hawkey, A., & Dallawaw, A. (2020). Application of acute whole-body vibration and lower-body exercise: Effects on concentric torque in lower-limb muscles. *Biomedical Human Kinetics, 12*, 157-165. https://doi.org/10.2478/bhk-2020-0020

Hibino, I., Takeda, C., Takahashi, K., & Aoyama, T. (2023). Effects of short-term whole-body vibration training on muscle strength, balance performance, and body composition. *The Journal of Physical Therapy Science, 35*, 414-420. https://doi.org/ 10.1589/jpts.35.414

Howe, T. E., Rochester, L., Jackson, A., Banks, P. M., & Blair, V. A. (2007). Exercise for improving balance in older people. *Cochrane Database of Systematic Reviews, 17*(4), 1-147 https://doi.org/10.1002/14651858.CD004963.pub2

Huang, M. Z., & Pang, M. Y. C. (2019). Muscle activity and vibration transmissibility during whole-body vibration in chronic stroke. *Scandinavian Journal Medicine Science in Sports, 29*, 816-825. https://doi.org/10.1111/sms.13408

Kaçoğlu, C. (2019). Akut tüm vücut vibrasyon antrenmanının ünilateral statik dengeye etkilerinin incelenmesi. *Gaziantep Üniversitesi Spor Bilimleri Dergisi, 4*(1), 144-156. https://doi.org/10.31680/gaunjss.528141

Karim, A., Roddey, T., Mitchell, K., Ortiz, A., & Olson, S. (2019). Immediate effect of whole body vibration on sauté height and balance in female professional contemporary dancers a randomized controlled trial. *Journal of Dance Medicine & Science, 23*(1), 3-10. https://doi.org/10.12678/1089-313X.23.1.3

Latash, M. L. (1998). *Neurophysiological basis of movement*. Human Kinetics.

Mahbub, M. H., Hase, R., Yamaguchi, N., Hiroshige, K., Harada, N., Bhuiyan, A. N. H., & Tanabe, T. (2020). Acute effects of whole-body vibration on peripheral blood flow, vibrotactile perception and balance in older adults. *International Journal of Environmental Research and Public Health, 17*(3), 1069. https://doi.org/10.3390/ijerph17031069

Marin, P. J., & Cochrane, D. J. (2021). The effects of whole-body vibration on EMG activity of the lower body muscles in supine static bridge position. *Journal of Musculoskeletal & Neuronal Interactions, 21*(1), 59-67.

McBride, J. M., Nuzzo, J. L., Dayne, A. M., Israetel, M. A., Nieman, D. C., & Triplett, N. T. (2010). Effect of an acute bout of whole body vibration exercise on muscle force output and motor neuron excitability. *The Journal of Strength & Conditioning Research, 24*(1), 184-189. https://doi.org/10.1519/JSC.0b013e31819b79cf

Moran, K., McNamara, B., & Luo, J. (2007) Effect of vibration training in maximal effort (70% 1RM) dynamic bicep curls. *Medicine and Science in Sports and Exercise, 39*, 526-533. https://doi.org/10.1249/mss.0b013e31802d11a7

Muratlı, S. (2003). *Antrenman bilimi yaklaşımıyla Çocuk ve spor*. Nobel.

Pollock, R. D., Provan, S., Martin, F. C., & Newham, D. J. (2011). The effects of whole body vibration on balance, joint position sense and cutaneous sensation. *European Journal of Applied Physiology, 111*, 3069-3077. https://doi.org/10.1007/s00421-011-1943-y

Pollock, R. D., Woledge, R. C., Mills, K. R., Martin, F. C., & Di Newham, J. (2010) Muscle activity and acceleration during whole body vibration: effect of frequency and amplitude. *Clin Biomech (Bristol, Avon), 25*(8), 840-846. https://doi.org/10.1016/j.clinbiomech.2010.05.004

Pope, Z. K., & DeFreitas, J. M. (2015). The effects of acute and prolonged muscle vibration on the function of the muscle spindle’s reflex arc. *Somatosensory & Motor Research, 32*(4), 254-261. https://doi.org/10.3109/08990220.2015.1091770

Rittweger, J. (2010). Vibration as an exercise modality: How it may work, and what its potential might be. *European Journal of Applied Physiology, 108*, 877-904. https://doi.org/10.1007/s00421-009-1303-3

Ritzmann, R., Kramer, A., Bernhardt, S., & Gollhofer, A. (2014). Whole body vibration training-improving balance control and muscle endurance. *Plos One, 9*(2), e89905. https://doi.org/10.1371/journal.pone.0089905

Roelants, M., Delecluse, C., & Verschueren, S. M. (2004). Whole-body-vibration training increases knee-extension strength and speed of movement in older women. *Journal of The American Geriatrics Society, 52*(6), 901-908. https://doi.org/10.1111/j.1532-5415.2004.52256.x

Roelants, M., Verschueren, S. M., Delecluse, C., Levin, O., & Stijnen, V. (2006). Whole-body-vibration-induced increase in leg muscle activity during different squat exercises. *Journal of Strength and Conditioning Research*, *20*(1), 124. https://doi.org/10.1519/R-16674.1

Rønnestad, B.R. (2004). Comparing the performance-enhancing effects of squats on a vibration platform with conventional squats in recreationally resistance-trained men. *Journal of Strength Conditioning Research, 18*(4), 839–845. https://doi.org/10.1519/14573.1

Schlee, G., & Reckmann, D., Milani, T. L. (2012). Whole body vibration training reduces plantar foot sensitivity but improves balance control of healthy subjects. *Neuroscience Letters, 506*, 70-73. https://doi.org/10.1016/j.neulet.2011.10.051

Spirduso, W. W. (1995). *Physical dimensions of aging*. Human Kinetics.

Stolzenberg, N., Belavy, D. L., Rawer, R., Felsenberg, D. (2013). Wholebody vibration versus proprioceptive training on postural control in post-menopausal osteopenic women. *Gait Posture, 38*, 416-420. https://doi.org/10.1016/j.gaitpost.2013.01.002

Şengür, E., Aktuğ, Z. B., ve Yılmaz, G. (2018). Futbolcularda alt ekstremiteye uygulanan akut vibrasyon antrenmanının şut hızı şut isabeti ve çeviklik performansı üzerine etkisinin incelenmesi. *CBÜ Beden Eğitimi ve Spor Bilimleri Dergisi, 14*(1), 56-65. https://doi.org/10.33459/cbubesbd.485183

Şimşek, D., ve Kırkaya, İ. (2021). *Tüm vücut vibrasyon antrenmanı, antrenman yöntemleri*. Efe Akademi.

Şimşek, E., & Ünver, Ş. (2020). The effect of acute vibration practices to upper extremity in handball players on shot velocity and hit accuracy. *African Educational Research Journal, 8*(1), 95-101. https://doi.org/10.30918/AERJ.8S1.20.015

Şimşek, E., Arslan H., Polat, M., & Koca, F. (2020). The effect of alpine skiing training on balance performance. *African Educational Research Journal, 8*(2), 357-362. https://doi.org/10.30918/AERJ.82.20.065

Şimşek, E., & Arslan, H. (2019). The examination of relationship between balance performances and some anthropometric characteristics of athletes in different branches. *International Journal of Applied Exercise Physiology, 8*(4), 88-94. https://doi.org/10.30918/AERJ.82.20.065

Tomás, R., Lee, V., & Going, S. (2011). The use of vibration exercise in clinical populations. *ACSM'S Health & Fitness Journal, 15*(6), 25-31. https://doi.org/10.1249/FIT.0b013e31823373e8

Torvinen, S., Sievänen, H., Järvinen, T. A., Pasanen, M., Kontulainen, S., & Kannus, P. (2002a). Effect of 4-min vertical whole body vibration on muscle performance and body balance: A randomized cross-over study. *International Journal of Sports Medicine, 23*(5), 374–379. https://doi.org/10.1055/s-2002-33148

Torvinen, S., Kannu, P., Sievänen, H., Järvinen, T. A., Pasanen, M., Kontulainen, S., Järvinen, T. L., Järvinen, M., Oja, P., & Vuori, I. (2002). Effect of a vibration exposure on muscular performance and body balance.

Randomized cross-over study. *Clinical Physiology and Functional Imaging, 22*(2), 145–152. https://doi.org/10.1046/j.1365-2281.2002.00410.x

Tsai, W.C., & Chen, Z.R. (2021). The acute effect of foam rolling and vibration foam rolling on drop jump performance. *International Journal of Environmental Research and Public Health, 18*(7), 3489. https://doi.org/10.3390/ijerph18073489

Turner, A. P, Sanderson, M. F, & Attwood, L. A. (2011). The acute effect of different frequencies of whole body vibration on counter countermovement jump performance. *Journal of Strength Conditioning Research, 25*(6), 1592-1597. https://doi.org/10.1519/JSC.0b013e3181df7fac

Usta-Demir, H. (2019). *Tüm beden vibrasyon antrenmanının denge, izokinetik kuvvet ve sıçrama performansına akut etkisi*. Yayınlanmamış Yüksek Lisans Tezi, Pamukkale Üniversitesi, Sağlık Bilimleri Enstitüsü, Antrenman ve Hareket Anabilim Dalı, Denizli.

Winter, D.A. (1995). Human balance and posture control during standing and walking. *Gait Posture, 3,* 193-214. https://doi.org/10.1016/0966-6362(96)82849-9

Yin, Y., Wang, J., Yu, Z., Zhou, L., Liu, X., Cai, H., & Sun, J. (2023). Does whole-body vibration training have a positive effect on balance and walking function in patients with stroke? A meta-analysis. *Frontiers in Human Neuroscience, 16*, 1076665. https://doi.org/10.3389/fnhum.2022.1076665