The Effects of Classical Music on Pain and Spinal Mobility During Stretching Exercises in Healthy Individuals

Sanem ŞENER[*], Elif CANTÜRK[**], Eda Ezgi TOPAL[***]

Abstract

Aim: The aim of this study was to examine the immediate effects of listening to classical music as a cognitive relaxation technique during stretching exercises on trunk flexibility and exercise-induced pain.

Method: This study was a randomized controlled trial in which 34 healthy male and female individuals aged between 18-22 years were divided into two groups: classical music listening group (n=17) and control group (n=17). Both groups performed static stretching exercises on the lumbal region and hamstring muscle groups for a total of 15 minutes. During the exercise, participants in the Classical Music Group listened to music with headphones. Control group did not listen to any music. Both groups underwent evaluation of their forward (Sit Reach Test) and lateral trunk flexibility (Trunk Lateral Flexion Test) before and after the exercise. Pain intensity during exercise was measured with Visual Analog Scale. Statistical analysis was performed using the R-Studio 1.4.1103 program, with a significance level of $p<0.05$.

Results: In both groups, there was an increase in all flexibility values compared to before the stretching exercise ($p<0.001$). Classical Music Group demonstrated greater improvements in flexibility values compared to the Control Group, except for the forward flexibility of the trunk ($p<0.05$). The two groups had no significant difference in pain levels experienced during static stretching exercises ($p>0.05$).

Conclusion: Performing stretching exercises while listening to classical music has been shown to increase the pain threshold. This decreased sensation of pain resulting from exercise can also lead to increased flexibility.

Keywords: Flexibility, stretching, music, pain intensity.

Özgün Araştırma Makalesi (Original Research Article)
Geliş / Received: 10.01.2024 & **Kabul / Accepted:** 05.08.2024
DOI: https://doi.org/10.38079/igusabder.1417431
[*] PhD, Asst. Prof., Bulent Ecevit University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Zonguldak, Türkiye. E-mail: sanemsener@yahoo.com ORCID https://orcid.org/0000-0003-1664-1016
[**] MSc, PT., Biruni University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Istanbul, Türkiye. E-mail: fztelif41@hotmail.com ORCID https://orcid.org/0000-0003-1405-9145
[***] MSc,PT., Istinye University, Institute of Graduate Education, Physiotherapy and Rehabilitation Program, Istanbul, Türkiye. E-mail: edaezgitopal@gmail.com ORCID https://orcid.org/0000-0003-2749-6264

ETHICAL STATEMENT: Ethics committee permission for the study was received from the Istanbul Arel University Ethical Committee (Date: 22/04/2019, Number: 2019/02) and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Sağlıklı Bireylerde Klasik Müziğin Germe Egzersizleri Sırasında Ağrı ve Spinal Mobilite Üzerine Anlık Etkileri

Öz

Amaç: Bu çalışmanın amacı, germe egzersizleri sırasında bilişsel bir rahatlama tekniği olan klasik müzik dinlemenin gövde esnekliği ve egzersiz kaynaklı ağrı üzerindeki anlık etkilerini incelemektir.

Yöntem: Bu çalışma, yaşları 18-22 arasında değişen 34 sağlıklı erkek ve kadın bireyin klasik müzik dinleme grubu (n=17) ve kontrol grubu (n=17) olmak üzere iki gruba ayrıldığı randomize kontrollü bir çalışmadır. Her iki gruba da toplam 15 dakika boyunca lumbal bölge ve hamstring kas grupları üzerinde statik germe egzersizleri yaptırılmıştır. Her iki gruba da toplam 15 dakika boyunca lumbal bölge ve hamstring kas grupları üzerinde statik germe egzersizleri yaptırılmıştır. Egzersiz sırasında Klasik Müzik Grubundaki katılımcılar kulaklıkla müzik dinlemiştir. Kontrol grubu herhangi bir müzik dinlememiştir. Her iki gruba da egzersizden önce ve sonra öne doğru uzanma (Sit Reach Test) ve yan gövde esnekliği (Trunk Lateral Flexion Test) değerlendirmesi yapılmıştır. Egzersiz sırasındaki ağrı şiddeti Görsel Analog Skala ile ölçülmüştür. İstatistiksel analiz R-Studio 1.4.1103 programı kullanılarak $p<0.05$ anlamlılık düzeyinde gerçekleştirilmiştir.

Bulgular: Her iki grupta germe egzersizi öncesine göre tüm esneklik değerlerinde artış görülmüştür ($p<0,001$). Klasik Müzik Grubu, gövdenin öne doğru esnekliği hariç, esneklik değerlerinde Kontrol Grubuna kıyasla daha fazla gelişme göstermiştir ($p<0.05$). Statik germe egzersizleri sırasında yaşanan ağrı düzeylerinde iki grup arasında anlamlı bir fark bulunmamıştır ($p>0.05$).

Sonuç: Klasik müzik dinlerken esneme egzersizleri yapmanın ağrı eşiğini yükselttiği gösterilmiştir. Egzersizden kaynaklanan bu azalmış ağrı hissi, esnekliğin artmasına da yol açabilir.

Anahtar Sözcükler: Esneklik, pasif germe, müzik, ağrı şiddeti.

Introduction

Physical Fitness has significant components related to health. These are muscle strength, endurance, body composition, cardiovascular fitness, and flexibility. Flexibility, specific to each joint of the body requires full range of motion during movement without discomfort or pain[1]. Flexibility exercises, which are an integral part of sports, can contribute to the comfortable performance of daily movements, improving posture, preventing sports injuries, increasing performance, improving and maintaining quality of life, and relaxation at a mental level.

One of the methods frequently preferred by physiotherapists for increasing flexibility is stretching exercises[2]. Streching is a movement applied by an external and/or internal force to the muscles and tendons of an individual to increase joint range of motion[3]. The literature on stretching exercises reveals the existence of numerous different types, including active, passive, dynamic, static, ballistic, and proprioceptive neuromuscular

facilitation[4]. Static stretching is frequently preferred by sedentary individuals at the beginning of exercises because of its low risk of injury. This type of stretching is applied in a controlled and slow manner with a constant force[5,6]. According to the literature, the stretch may cause increased joint movement because it inhibits motor nerves and increases the length of tendons[7]. In addition to studies show that the maximum increase in joint movement openness was achieved after at least 3 weeks of a stretching program[8,9]. Studies have also shown that acute static stretching increases joint motion opennes, decreases muscular tendon hardness, and reduces passive torque[10,11]. The increase in joint movement openness of stretching exercises is generally explained by sensory theory and an increase in neuromuscular relaxation, viscoelastic deformation, plastic deformity, and sarcomer series[12,13]. According to the sensory theory, the nosiseptive signals that occur during stretching can be suppressed by the afferent input from the muscle and joint. Thus, since the last point of stretching is the maximum pain tolerated by the person, the stretch tolerance is revealed late during the application, and the muscle stretchability is increased[14].

In this context, people with low flexibility have a low tolerance for stretching exercises because their muscles and tendons are tense and they feel uncomfortable during exercise. Stretching also contributes to general mental well-being because it increases flexibility. Because it promotes self-awareness, it is also an integral part of yoga exercises[15,16]. The increased flexibility and stretchability of the muscle, which is also defined as providing full movement clarity of the appendix, can also be affected by a person's emotional states. But this can happen when it's done consciously and willingly.

Cognitive Behavioral Techniques are approaches that exclude pharmacological methods to provide relaxation, provide mental and physical relaxation, and reduce pain. These techniques are relaxation techniques, reorientation, imagination, cognitive strategies, and music[12].

One of the central tenets of cognitive behavioral therapy is that the relationship between music and human beings has existed since ancient times[17]. In human culture, it may have evolved before oral communication. Studies in recent years on people who were and are not musicians support the famous philosopher Socrates of the 4th century B.C.E. that "Music is the food of the soul"[17,18]. Because of the neuronal structures in the brain, non-musicals have the ability to adapt to music[19]. Structures in the brain, such as corpus callosum, motor cortex, prefrontal cortex, amygdala, accumbens nucleus, sensory cortex, occipital cortex and temporal cortex, hippocampus and cerebellum, work as a whole and

provide physiological and psychological responses while preparing the ground for motor activities such as rhythm-keeping and dancing[18,20]. In the brain, the thalamus determines the state of the music based on the information it receives from the temporal lobe and allows it to move through the right hemisphere. Hormones such as enkephalin and endorphins, which are secreted by the stimulation of the right hemisphere and limbic system by music, reduce pain through psychophysiological reactions[21,22]. Classical music listened to patients lying in surgical intensive care units has been shown to reduce pain and anxiety[23]. In addition to the treatment of diseases, music is employed in a variety of contexts to enhance motivation in sports and to facilitate relaxation, for instance, in meditation. A meta-analytic study that examined the four potential benefits of music on sports (psychological responses, physiological reactions, psychophysical responses, and performance results) examined 139 English-language publications with a total of 3599 participants from 1911 to 31 December 2017. Participants who did various physical activities accompanied by music and those who did not do music found that listening to music during physical activity improved physical performance like an ergogenic agent, reduced perceived effort, and increased physiological efficiency[24].

The aim of this study is to study the instantaneous effect of the combination of static stretching exercises with music, which is one of the cognitive relaxation techniques, on flexibility, and our other aim is to investigate the effect of stretching exercise on spinal mobility (spinal flexibility), which is performed on the hamstring muscle group and on lumbar extensors, along with classical Baroque music.

Material and Methods

Research Design

This study was planned as an experimental randomized controlled single-blind review. The participants determined by the simple random method in the research were to study and control group with the coin toss method. The participants, who were divided into two groups (Study n= 17, Control = 17), were stratified by gender. Before the study, participants who agreed to participate in the study information about the protocol of the study was given. Before the study, the participants were asked to answer the questions in the form containing their socio-demographic information (age, gender, regular exercise status, smoking). Anthropometric measurements (Sit and Reach Test, and Trunk Lateral Flexion Distance) were measured with a tape measure before and immediately after the exercises and recorded in centimeters. Pain intensity was

evaluated during exercise. In addition, participants were informed that they should refrain from consuming food or drink for a minimum of two hours. In the study, the researcher who taught and had the exercise done was the same. The researcher who made the first and last measurements is different and does not have information about the groups of participants. Participants were not informed about which group they belonged to.

Inclusion and Exclusion Criteria

The study included male and female volunteers aged 18-22 who were actively pursuing education in the physiotherapy and rehabilitation department.

The study excluded participants with a history of spinal surgery, diagnosed intervertebral disc herniation, neurological or orthopedic diseases, congenital morphological disorders, acute or chronic illnesses, physical or mental disabilities that prevent exercise, or those who declined to participate.

Research Group

Male and female students between the ages of 18-22 who were active students in the physiotherapy and rehabilitation department of the Faculty of Health Sciences in the 2018-2019 academic year at a private university in Istanbul, were included in the study. The sample size was calculated using the G-Power 3.1.9.2 Power Analysis program. It was planned to be performed with 34 students (17 experiments, 17 controls) actively enrolled in the physiotherapy and rehabilitation department, with a significance level of 0.01, an effect size of 0.60, and a power of 95%[25,26].

After determining the study and control groups, exercises were carried out in groups of 5-6 people in the aerobic exercise room of the university, accompanied by a physiotherapist. The participants in the groups were randomly assigned to different groups, and the participants were prevented from learning which group they were in. Once the study and control groups had been established, the exercises were conducted in groups of five to six volunteers in the university's aerobic exercise hall under the supervision of a physiotherapist. The participants in the groups were mixed, and the participant was prevented from learning which group he was in. The study received approval from the Istanbul Arel University Ethical Committee (2019/02). In accordance with the Declaration of Helsinki, all the information was presented to the participants with the informed consent form given before the study, and the informed consent form was signed.

Exercise Protocol

Before the commencement of the study, all participants were instructed in the performance of stretching exercises for the lumbar region and hamstring muscles by a physiotherapist. Subsequently, participants were instructed to perform the aforementioned exercises independently. The duration of each exercise was 30 seconds, with 10 repetitions, and the total time spent on the exercises was 15 minutes. All stretching exercises were performed with 10 repetitions, comprising 10 repetitions on the back, 10 repetitions on the right leg, and 10 repetitions on the left leg. The hamstring (hind leg) muscle stretching exercise is performed in the supine position. One leg is extended from the hip, while the other leg remains on the ground. The efficacy of the stretching exercise can be enhanced by pulling a sheet under the bent and lifted foot towards the chest with both hands[27]. The identical procedure was then repeated for the other leg. The participants listened to the compositions of the Baroque artist Johann Sebastian Bach with their personal headphones for 15 minutes, while the control group participants performed the same exercises without music.

Measurements

Height (cm): While the participants were in an anatomical position and standing upright with bare feet, the distance between the point where the feet hit the ground and the vertex was measured with a non-flexible tape measure and recorded in centimeters (cm).

Body weight (kg): The participants were barefoot, wearing a T-shirt and shorts/tights, and were measured with a Tanita scale with 0.01kg sensitivity, and their values were recorded in kilograms (kg).

Body mass index (BMI): It was obtained and recorded by dividing body weight by height (kg/m2)[28].

Pain Level – was evaluated during activity with the Visual Analogue Scale (VAS) (0-10 cm); The participant was told that zero (0) means "I have no pain" and 10 means "I have unbearable pain", and the participant was asked to mark on a 10 cm vertical scale, and the value was measured with a tape measure and recorded[29].

Sit and Reach Test (SR): To evaluate the trunk forward flexibility of the participants, a sit-reach table with a length of 35 cm, a width of 45 cm, and a height of 32 cm was employed. Following the participant's leaning on the table with the knees in full

extension and the feet upright, they were instructed to extend the trunk forwards and push the apparatus on the table forwards with the elbows stretched in full extension, before waiting for 1-2 seconds. Push and wait 1-2 seconds. The test was repeated twice, and the best result was recorded. The apparatus on the coffee table is 20 cm, and it is measured as (- cm) if it falls behind this point, and as (+ cm) if it goes beyond this point[28,29].

Trunk Lateral Bending Test (TLBT) – (cm); The study employed a methodology designed to assess the flexibility of the participants on both sides. The participant was positioned in a standing posture, with feet positioned shoulder-width apart and both arms extended parallel to the side of the body. Subsequently, the distal ends of both hands were marked, after which the subject was instructed to place their hand on their body and slide it to the point that they could reach. The distance between the final and initial marked points was quantified with a measuring tape and recorded in centimeters[30].

Results

A total of 40 male and female volunteer participants were included in this study, including a classical music group (n = 20) and a control group (n = 20).

Table 1. Sociodemographic data of participants

		Classical Music Group (n=20)	**Control Group (n=20)**	**p**
Variables		**M±SD**	**M±SD**	
Age (year)		20.40 ± 1.14	20.85 ± 1.09	0.231[a]
Length (m)		1.73 ± 0.09	1.69 ± 0.09	0.155[b]
Weight (kg)		66.75 ± 11.10	64.80 ± 14.99	0.643[b]
BMI (kg/m²)		22.28 ± 2.62	22.58 ± 3.49	0.760[b]
Gender	Male	8 (%40.0)	8 (%40.0)	1.000[c]
	Female	12 (%60.0)	12 (%60.0)	
Smoking	Yes	9 (%45.0)	7 (%35.0)	0.747[d]
	No	11 (%55.0)	13 (%65.0)	
Exercise Habit	Yes	4 (%20.0)	5 (%25.0)	1.000[b]
	No	16 (%80.0)	15 (%75.0)	

M: mean, SD: Standart Deviation, m: meters, kg: kilograms, BMI: Body Mass Index, [a] Mann Whitney U test, [b] Independent Sample t-Test, [c] Yates Chi-square test, [d] Fisher Chi-square test

There is no statistically significant difference between the groups in terms of average age, height, weight, body mass index, gender, smoking and exercise habits (>0.05) (Table 1).

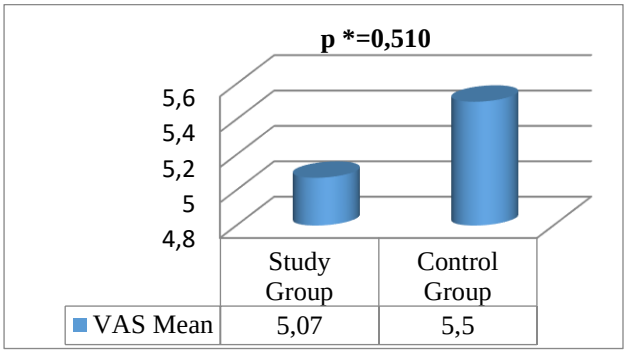
Table 2. Comparison of flexibility tests before exercise

	Classical Music Group (n=20)	**Control Group (n=20)**	**p***
Variables	**M± SD**	**M± SD**	
Sit and Reach Test	-3.28 ± 9.05	-6.25 ± 8.17	0.284
Trunk Right LB Test	21.16 ± 3.16	21.92 ± 3.74	0.492
Trunk Left LB Test	21.37 ± 3.07	21.63 ± 4.22	0.822

M: mean, SD: Standart Deviation, LB: Lateral Bending, VAS: Visual Pain Scale, * Independent Sample t-test

Before the commencement of the exercise, all participants underwent a comprehensive evaluation of their flexibility of the trunk forward and to both sides, right and left. The results demonstrated that there was no statistically significant difference between the groups (p > 0.05). Table 2 presents the results of the flexibility evaluation conducted on the participants.

Figure 1. Intergroup pain intensity values during exercise



VAS: Visual Pain Scale, * Independent Sample t-test

There is no statistically significant difference between the groups in the level of pain they felt during exercise (p = 0.510). Pain levels are shown in Figure 1.

Table 3. Comparison of intra-group flexibility test values before and after exercise

	Classical Music Group (n=20)		**p***	**Control Group (n=20)**		**p***
Variables	**Before Exercise**	**After Exercise**		**Before Exercise**	**After Exercise**	
	M±SD	**M±SD**		**M±SD**	**M±SD**	
Sit and Reach Test	-3.28 ± 9.05	1.38 ± 9.31	**<0.001**	-6.25 ± 8.17	-1.57 ± 8.82	**<0.001**
Trunk Right LB Test	21.16 ± 3.16	24.12 ± 2.64	**<0.001**	21.92 ± 3.74	23.88 ± 3.44	**<0.001**
Trunk Left LB Test	21.37 ± 3.07	24.26 ± 2.90	**<0.001**	21.63 ± 4.22	23.37 ± 3.47	**<0.001**

*Independent Sample t-Test, M: mean, SD: Standart Deviation, LB: Lateral Bending

Table 3 presents the results of the flexibility evaluation conducted on the participants before and after the in-group exercise. An increase in flexibility levels was observed in all participants compared to before the stretching exercise (<0.05).

Table 4. Comparison of flexibility test measurement difference values before and after exercise between groups

	Classical Music Group (n=20)	**Control Group (n=20)**	**p***
Variables	**M± SD**	**M± SD**	
Sit and Reach Test	4.66 ± 3.30	4.48 ± 3.44	0.862
Trunk Right LB Test	2.96 ± 1.46	1.96 ± 1.48	**0.023**
Trunk Left LB Test	2.90 ± 2.22	1.74 ± 1.68	**0.028**

*Mann Whitney U test, M: mean, SD: Standart Deviation, LB: Lateral Bending

Table 4 displays the measurement difference values of the participants before and after exercise. The difference in lateral flexibility levels of the trunk in the classical music group participants is statistically greater than the difference in the control group participants (<0.05). The difference in trunk forward flexibility is not significant (>0.05).

Discussion

Although an increase in flexibility was detected in both groups in the evaluations made immediately after the stretching exercises, it was determined that the increase in lateral flexibility values of the trunk was greater in the classical music group. There were no significant changes in trunk forward flexibility.

Listening to music during exercise increases motivation, provides relaxation, and improves mood[31,32]. There are many studies in the literature showing that music reduces pain in interventional health practices (during and after various surgical interventions, during radiological procedures, in labor pain and palliative care, etc.)[33-37]. Exercise practices are used by physiotherapists and exercise specialists to benefit from the healing effects of physical activity and to maintain and improve the state of health in healthy individuals[38]. Static stretching exercises are a part of these practices and are one of the safest methods used to increase flexibility[6]. In these exercises, since the control is in the participant who performs the exercise, the participant maintains the position at which he/she feels the pain during muscle stretching[3]. In this study, participants in both groups stopped at the point where they could tolerate pain and maintained their position for 30 seconds. A comparison of the groups revealed that, although the intensity of pain was similar, there was a discrepancy in muscle tension. During the exercise, the point at which participants who listened to classical music could tolerate muscle pain was found to be greater than that of the control group, indicating a higher level of muscle tension. Consequently, greater stretching was achieved on both sides of the body in the classical music group. This suggests that classical music raises the pain threshold during exercise. Numerous studies in the literature demonstrate the efficacy of classical music in increasing the pain threshold. These findings align with the results of our study[39,40]. Furthermore, literature has indicated that music does not alleviate pain. These studies have implemented interventions that are significantly more extreme than standard post-anesthesia care practices[41]. The trunk's forward flexibility is associated with the lumbal extensors, gastrocnemius-soleus, and hamstring muscle groups[42]. In our experiment, only the hamstring muscles were stretched. Obtaining comparable outcomes in forward flexibility values between the groups may be attributed to differences in lumbar flexibility and gastrocnemius-soleus muscle tightness among the participants.

The study results indicate that after undergoing static stretching, flexibility values for participants in both groups significantly increased compared to pre-exercise levels. A comparison study of the impacts of static and dynamic stretching exercises on flexibility

found that the former was more effective[43]. A study compared various types of static stretching exercises and found that all types had positive effects on joint range of motion and passive torque. Furthermore, the study concluded that stretching intensity was more crucial than the duration of stretching to increase joint range of motion[44]. In this research, we instructed participants from both groups to stretch to their highest tolerable intensity level (100%) and maintain the tension level. Participants in both groups performed stretching exercises for identical periods. Our study's findings indicate consistent with previous literature that high-intensity static stretching exercises lead to an immediate increase in flexibility.

Strengths and Limitations of the Study

The research is characterized by several strengths. Specifically, the sample size was determined using a power analysis before the study, and the study was randomized and controlled. Additionally, the participants were unaware of their group allocation, and all exercises were taught by the same researcher to ensure the safety of the study. All data were collected by the same researcher, adding to the research's validity.

The limitations of our study include the evaluation of only the immediate effects of stretching exercises accompanied by classical music without assessing their medium and long-term effects. Additionally, no comparisons were made with stretching exercises accompanied by different types of music. Therefore, additional research is necessary to examine the impact of stretching exercises accompanied by different types of music, such as nature sounds.

Conclusion

The results of this study showed that listening to classical music during static stretching exercises increased flexibility in a short time in healthy individuals. Listening to classical music during individual exercise or in exercise facilities as an alternative to other types of music can provide a time and cost-efficient stretch exercise.

Relevance to Clinical Practice

This study shows that listening to classical music during stretching exercises has positive effects on safety, cost, and flexibility. Healthy individuals who perform stretching exercises alone or in groups can benefit more from listening to classical music than from flexibility exercises.

Acknowledgements

No financial support was received for this study.

Contributions

Study design: SŞ, EC, EET; Clinical Data Collectıon Study; SŞ, EC, Data collection and analysis: SŞ, EC, EET; Formal order of the work: SŞ, EET; Manuscript preparation: SŞ, EC, EET

Conflict of interest

The authors declare that they have no conflicts of interest.

REFERENCES

1. Corbin CB, Pangrazi RP, Franks BD. Definitions: Health, fitness, and physical activity. *Pres Counc Phys Fit Sports Res Dig*. 2000;3:1–11.

2. Mannerkorpi K. Exercise in fibromyalgia. *Curr Opin Rheumatol*. 2005;17(2):190-194.

3. Apostolopoulos N, Metsios GS, Flouris AD, Koutedakis Y, Wyon MA. The relevance of stretch intensity and position—a systematic review. *Front Psychol*. 2015;6:1128.

4. Zakas A, Doganis G, Papakonstandinou V, Sentelidis T, Vamvakoudis E. Acute effects of static stretching duration on isokinetic peak torque production of soccer players. *J Bodywork Mov Ther*. 2006;10(2):89-95.

5. Matsuo S, Suzuki S, Iwata M, Hatano G, Nosaka K. Changes in force and stiffness after static stretching of eccentrically-damaged hamstrings. *J Strength Cond Res*. 2015;115:981-991.

6. Page P. Current concepts in muscle stretching for exercise and rehabilitation. *Int J Sports Phys Ther*. 2012;7(1):109.

7. Nelson AG, Kokkonen J. *Stretching Anatomy*. Champaign, IL: Human Kinetics, 2007.

8. Ben M, Harvey LA. Regular stretch does not increase muscle extensibility: a randomized controlled trial. *Scand J Med Sci Sports*. 2010;20(1):136–44.

9. Ylinen J, Kankainen T, Kautiainen H, Rezasoltani A, Kuukkanen T, Häkkinen A. Effect of stretching on hamstring muscle compliance. *J Rehabil Med.* 2009;41(1):80–4.

10. Kay AD, Husbands-Beasley J, Blazevich AJ. Effects of contract-relax, static stretching, and isometric contractions on muscle-tendon mechanics. *Med Sci Sports Exerc.* 2015;47:2181–2190.

11. Nakamura M, Ikezoe T, Takeno Y, Ichihashi N. Time course of changes in passive properties of the gastrocnemius muscle–tendon unit during 5 min of static stretching. *Manual Ther.* 2013;18(3):211–215.

12. Weppler CH, Magnusson SP. Increasing muscle extensibility: a matter of increasing length or modifying sensation. *Phys Ther.* 2010;90(3):438-449.

13. Moritani T, Devries HA. Potential for gross muscle hypertrophy in older men. *J Gerontol* 1980;35(5):672-682.

14. Law RY, Harvey LA, Nicholas MK, Tonkin L, De Sousa M, Finniss DG. Stretch exercises increase tolerance to stretch in patients with chronic musculoskeletal pain: a randomized controlled trial. *Phys Ther.* 2009;89(10):1016-1026.

15. Power K, Behm D, Cahill F, et al. An acute bout of static stretching: effects on force and jumping performance. *Med Sci Sports Exerc.* 2004;36(8):1389-1396.

16. Magnusson SP, Simonsen EB, Aagaard P, Kjaer M. Biomechanical responses to repeated stretches in human hamstring muscle in vivo. *Am J Sports Med.* 1996;24(5):622-628.

17. Özveren H. Ağrı kontrolünde farmakolojik olmayan yöntemler. *Sağlık Bilimleri Fakültesi Hemşirelik Dergisi.* 2011;18(1):83-92.

18. Torun S. Müziğin Beynimizdeki Yolculuğu. *Osmangazi Journal of Medicine.* 2016;38(1).

19. Mithen SJ. *The Singing Neanderthals: The Origins of Music, Language, Mind, and Body*. Harvard University Press; 2006.

20. Terry PC, Karageorghis CI, Curran ML, Martin OV, Parsons-Smith RLJPb. Effects of music in exercise and sport: A meta-analytic review. *Psychological Bulletin.* 2020;146(2):91.

21. Karaaslan Ş. Müziğin Ameliyat Sonrası Ağrı Üzerine Etkisi, [yüksek lisans tezi], İnönü Üniversitesi Sağlık Bilimleri Enstitüsü; 2014.

22. Karamızrak N. Ses ve müziğin organları iyileştirici etkisi. *Koşuyolu Heart Journal* 2014;17(1):54-57.

23. Elliott D. The effects of music and muscle relaxation on patient anxiety in a coronary care unit. *Heart & Lung: The Journal of Critical Care*. 1994;23(1):27-35.

24. O'Sullivan RJ. A musical road to recovery: music in intensive care. *Intensive Care Nursing*. 1991;7(3):160-163.

25. Munro S, Mount B. Music therapy in palliative care. *Canadian Medical Association Journal*. 1978;119(9):1029.

26. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*. 2009;41(4):1149-1160.

27. Otman A, Köse N, Karakaya MG. *Egzersiz Tedavisinde Temel Prensipler ve Yöntemler*. Meteksan Aş. 2006:21-51.

28. Sayin YY, Akyolcu N. Comparison of pain scale preferences and pain intensity according to pain scales among Turkish Patients: a descriptive study. *Pain Management Nursing*. 2014;15(1):156-164.

29. López-Miñarro PA, Rodríguez-García PL. Hamstring muscle extensibility influences the criterion-related validity of sit-and-reach and toe-touch tests. *The Journal of Strength & Conditioning Research*. 2010;24(4):1013-1018.

30. Ince G, Sarpel T, Durgun B, Erdogan S. Effects of a multimodal exercise program for people with ankylosing spondylitis. *Physical Therapy*. 2006;86(7):924-935.

31. Hutchinson JC, Jones L, Vitti SN, et al. The influence of self-selected music on affect-regulated exercise intensity and remembered pleasure during treadmill running. *Sport, Exercise, and Performance Psychology*. 2018;7(1):80.

32. Karageorghis CI, Bigliassi M, Tayara K, et al. A grounded theory of music use in the psychological preparation of academy soccer players. *Sport, Exercise, and Performance Psychology*. 2018;7(2):109.

33. Kulkarni S, Johnson P, Kettles S, et al. Music during interventional radiological procedures, effect on sedation, pain and anxiety: a randomised controlled trial. *The British Journal of Radiology*. 2012;85(1016):1059-1063.

34. Taghinejad H, Delpisheh A, Suhrabi Z. Comparison between massage and music therapies to relieve the severity of labor pain. *Women's Health*. 2010;6(3):377-381.

35. Gutgsell KJ, Schluchter M, Margevicius S, et al. Music therapy reduces pain in palliative care patients: a randomized controlled trial. *Journal of Pain and Symptom Management*. 2013;45(5):822-831.

36. Pradit L, Tantipalakorn C, Charoenkwan K, et al. Efficacy of listening to music on pain reduction during colposcopy-directed cervical biopsy: a randomized. controlled trial. *Medicina*. 2022;58(3):429.

37. Choi EK, Baek J, Lee D. Effect on music therapy on quality of recovery and postoperative pain after gynecological laparoscopy. *Medicina*. 2023;102(9).

38. Clark IN, Baker FA, Peiris CL et al. Participant-selected music and physical activity in older adults following cardiac rehabilitation: A randomized controlled trial. *Clinical Rehabilitation*. 2017;31(3):329-339.

39. Howlin C, Stapleton A, Rooney B. Tune out pain: Agency and active engagement predict decreases in pain intensity after music listening. *PloS One*. 2022;17(8):e0271329.

40. Good M, Stanton-Hicks M, Grass JA, et al. Relaxation and music to reduce postsurgical pain. *Journal of Advanced Nursing*. 2001;33(2):208-215.

41. de Araújo Azi LMT, Azi ML, Viana MM, et al. Benefits of intraoperative music on orthopedic surgeries under spinal anesthesia: A randomized clinical trial. *Complementary Therapies in Medicine*. 2021;63:102777.

42. Nikzad S, Pirouzi S, Taghizadeh S. Hemmati L. Relationship between hamstring flexibility and extensor muscle activity during a trunk flexion task. *Journal of Chiropractic Medicine*. 2020;19(1):21-27.

43. Bandy WD, Irion JM, Briggler M. The effect of static stretch and dynamic range of motion training on the flexibility of the hamstring muscles. *Journal of Orthopaedic & Sports Physical Therapy*. 1998;27(4):295-300.

44. Freitas S, Vaz J, Bruno P, et al. Stretching effects: high-intensity & moderate-duration vs. low-intensity & long-duration. *International Journal of Sports Medicine*. 2015:239-244.