

Investigation of the effect of proprioceptive neuromuscular facilitation stretching exercises applied with karate training on Oi Tsuki Chudan technical performance and delayed-onset muscle soreness in visually impaired individuals

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Abstract: The World Karate Federation (WKF) has developed para-karate discipline as an adapted form of karate in order to encourage disabled individuals to participate in the sport. In para-karate, visually impaired individuals aged 16 and over can participate in the competitions only in the kata branch in two categories, male and female, in the K-10 class where necessary adaptations are made. In this research, it was aimed to investigate the effect of proprioceptive neuromuscular facilitation (PNF) stretching exercises applied together with karate training on "Oi Tsuki Chudan" technical performance and delayed muscle pain in visually impaired individuals who can form para-karate infrastructure. Visually impaired individuals between the ages of 10 and 12 studying in Ankara province voluntarily participated in the research. In the research, the study group received PNF stretching exercises together with karate training in physical education class hours 1 day a week for 12 weeks, while the control group received only karate training. In this study, a numbered pain scale was used to measure the severity of delayed muscle pain. "Oi Tsuki Chudan" technical performance analysis was evaluated by a karate national team technical committee member, a national karate referee, two assistant karate coaches, and the researchers through video recordings of five different criteria. The SigmaPlot 11.0 program was used for data analysis. As a result of the research, it was seen that PNF stretching exercises applied to visually impaired individuals together with karate training improved the technical performance of "Oi Tsuki Chudan" and reduced delayed muscle pain.

Keywords: Visually Impaired, Karate, Proprioceptive Neuromuscular Facilitation (PNF), Technical Performance, Delayed-Onset Muscle Soreness (DOMS)

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INTRODUCTION

The importance of sports training for individuals with disabilities is frequently discussed today. Visually impaired individuals have difficulties in social life due to mobility limitations and lack of experience. The ability to move independently, movement motivation and perception of disability can be negatively affected. For these reasons, diversification of sportive activities and different individual applications gain importance. Restricted movement skills may lead to decreased muscle activity and, therefore, to short muscle lengths. While short muscles facilitate the occurrence of injuries, they may also cause increased pain due to muscle use.

Adapted sports are seen as the best tool to support other developmental aspects of disabled

INVESTIGATION OF THE EFFECT OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION STRETCHING EXERCISES APPLIED WITH KARATE TRAINING

individuals, along with their functional movement capacities, and to integrate them into society. Adapted sports known as "Para" allow individuals with special needs to see themselves as athletes rather than disabled and give them a social status (Özer, 2020; Di Palma et al., 2016).

Disabled people can participate in different sports, depending on their disability status and degree. The most common sports among the visually impaired are goalball, torball, bowling, football, chess, and athletics (Çalışkan et al., 2010).

Unlike the sports performed by visually impaired people in the literature and scientific studies in this field, the sport of "Karate-do", in which basic posture, attack, defense, and walking forms are used, has become a field in which disabled individuals can participate (Bertozzi et al., 2020; Jimeno, 2020; Rodriguez et al., 2021; Yavaşoğlu & Marangoz, 2023). Karate-do, whose homeland is Japan, is a combat and defense sport (Alpay, 2016; Dilekçi, 2021; Çetintaş & Yavuz, 2021). The World Karate Federation (WKF) established the Para-Karate Commission in 2006 to make karate suitable for the participation of disabled people and to encourage their involvement in sports. Since then, Para-Karate has become a new modality of karate in World Karate Federation organizations (Yavaşoğlu & Marangoz, 2023).

In the Para-Karate modality, visually impaired, physically disabled, mentally disabled, and individuals with Down syndrome perform as competitors in national and international organizations (Yavaşoğlu & Marangoz, 2023). The fact that these individuals, who had mobility limitations when they started karate, can perform at the level of competitors in high-segment organizations in the following process reveals how significant the improvement in their functional movement capacities and technical performances is. In adapting to karate training that provides this development, we may encounter what we know as "delayed-onset muscle pain" in the muscles of disabled individuals.

Delayed-onset muscle pain is a severe pain sensation following unusual muscle activity. This is the main feature that occurs only in eccentric muscle soreness. Unlike other muscle aches, delayed-onset muscle soreness occurs due to metabolic deficiencies during or after exercise. Delayed-onset muscle soreness is due to localized microtrauma to the muscle. The key site for this inflammation is between adjacent sarcomeres or within the Z-bands. This inflammatory reaction cannot lead to high levels of streptokinase (CK) in the blood following exercise. This enzyme diffuses into the bloodstream following muscle injury (Baltacı, 2016).

To minimize delayed-onset muscle soreness while improving technical performance, it is curious whether proprioceptive neuromuscular facilitation (PNF) stretching exercises applied with karate training in this study contribute to the development of technical performance in para-karate as a result of the freedom of movement that will occur and whether they have an effect on delayed-onset muscle soreness as a result of accelerating muscular recovery.

Stretching exercises consist of trying activities of the muscles and tendons involved in the movement to increase the individual's sporting or daily life performance efficiency. Stretching exercises increase the amount of oxygen in muscle cells by helping fresh blood flow to the muscles. In addition, stretching exercises applied after training increase intracellular protein synthesis and prevent protein degradation by facilitating the passage of amino acids into muscle cells. One of the stretching exercise applications is the PNF method (Bilge, 2013).

Proprioceptive Neuromuscular Facilitation Stretching Method: PNF is created from word abbreviations in proprioceptive neuromuscular facilitation expressions. A neurophysiologist and physicist, Herman Kabat developed PNF techniques at the Kabat-Keiser Institute between 1946 and 1951 (Livanelioğlu & Erden, 1998). PNF stretching exercise is an elastic method that regulates, improves, and accelerates neuromuscular relations and works through sensory receptors (Yılmaz et al., 2022). PNF stretching exercises are a unique technique used in the physical therapy-rehabilitation process and to improve sporting performance. PNF techniques consist of muscle relaxation, hold relaxation, slow antagonist holds relaxation, agonist contraction, muscle relaxation with agonist contraction, and have relaxation with agonist contraction (Baltacı, 2016).

PNF-type stretching exercises increase muscle strength because they use static contractions. In other words, the athlete becomes more flexible and stronger, especially at the limit points of the movement angle (Baltacı, 2016; Bilge, 2013). In addition, applying PNF stretching exercises together with static stretching after training accelerates muscle recovery and blood flow in the muscles while taking tension in the muscles (Bilge, 2013).

Studies have shown that PNF stretching exercises have an acute effect on recovery by reducing fatigue and have a positive effect on athletic technique by improving joint mobility (Ai & Hang, 2023; Avorah & Putri, 2024). Based on the aforementioned scientific studies, the problem statement of this research is that PNF stretching exercises applied in combination with karate training have an effect on the technical performance of "Oi Tsuki Chudan" and delayed onset muscle soreness.

From this point of view, this study aimed to investigate the effect of PNF stretching exercises applied together with karate training on "Oi Tsuki Chudan" technical performance and delayed-onset muscle pain in visually impaired individuals who can form the infrastructure of para-karate.

MATERIALS AND METHODS

Model of Research

This research is experimental with a study and control group, including pre-test and post-test evaluations. The individuals who voluntarily participated in the study were subjected to delayed muscle pain measurement and technical performance analysis.

Population and Sample of the Research

The population of this research is all individuals between the ages of 10 and 12 who are candidates to become visually impaired para-karate athletes. The research sample consists of individuals between the ages of 10 and 12 who are studying in Ankara and voluntarily participated in the analysis.

Research Group

A total of eight visually impaired individuals participated in the research. Four participants were included in the research as the study group and four as the control group. In the research, PNF stretching exercises were applied to the study group with karate training in physical education class hours 1 day a week for 12 weeks, while the control group received only karate training.

The necessary permissions for this research were obtained from the Gazi University Ethics Committee, 2023-356, dated February 7, 2023.

Inclusion criteria of the participants in the study:

- a) the presence of a visually impaired person,
- b) be between 10 and 12 years old.
- c) not to have any other disability associated with the visual impairment.
- d) have never practiced sports or taken part in sports competitions.

Exclusion criteria for the study participants:

- a) had a physical injury or surgery in the last six months
- b) Failure to attend 50% of the total number of training sessions
- c) Failure to complete any of the measurements
- d) Voluntary withdrawal from the study at any stage

Research Method and Data Collection

The karate training applied to visually impaired individuals for 12 weeks is basic technical training called "Kihon". These training were applied in a suitable ground and environment in the presence of two Turkish karate national athletes and coaches with seniority from "Ni & San" dan, who are experts in their field. Practices are not paired but individual performance. In the "Kata" branch, where disabled individuals can compete, individuals present individual series with a logical sequence, synchronization, and rhythm of basic technical combinations previously determined and officially accepted. One of the most commonly used techniques in these kata performances is the "Oi Tsuki Chudan" technique, one of the most basic techniques. Therefore, the "Oi Tsuki Chudan" technique was analyzed in this study. For 12 weeks, PNF stretching exercises were applied to the study group together with karate training, and its effect on technical performance was analyzed. The control group only did karate training.

Since the Oi Tsuki Chudan technique is a technique that is performed using both the lower and upper extremities and requires displacement skills in deep stances (dachi), PNF stretching exercises were applied to both extremities. In the study group, the "flexion-abduction-external rotation" elbow straight pattern was used for upper extremity PNF stretching exercises, and the "contract-relax" technique was used for lower extremity PNF stretching exercises with the right and left legs at 90 degrees of flexion.

This study used the numbered pain scale to measure the severity of delayed-onset muscle pain. This scale is scored horizontally from 0 to 10 (0=no pain, 10=intolerable pain). The study and control groups were asked to verbally rate the pain they felt in their muscles between 0 and 10 in acute immediately after training and delayed 6, 24, and 48 hours after exercise. Oi tsuki chudan technical performance was analyzed and evaluated by a karate national team technical committee member, a national karate referee, two assistant karate coaches, and researchers through video recordings of five different criteria. These criteria were:

1. Zenkutsu dachi depth,
2. Zenkutsu dachi distance,
3. Upper body position,
4. Oi tsuki arm angle,
5. Oi tsuki arm position.

INVESTIGATION OF THE EFFECT OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION
STRETCHING EXERCISES APPLIED WITH KARATE TRAINING

A maximum of 3 points will be awarded for each criterion. A maximum of 15 points can be obtained in total. The participants' pre-test and post-test technical analysis scores were recorded as a total.

Analysis of Data

The SigmaPlot 11.0 program was used for data analysis. In the pre-and post-test comparisons, a paired t-test was used for normally distributed data, and a Wilcoxon test was used for non-normally distributed data. The t-test was used for normally distributed data in comparing two independent groups, and the Mann Whitney-U test was used for non-normally distributed data.

RESULTS

Table 1. Analysis of the Study Group Oi Tsuki Chudan Technical Performance Pre-Post Test and Control Group Oi Tsuki Chudan Technical Performance Pre-Post Test Values

Oi Tsuki Chudan Technical	Study Group (n= 4)		Control Group (n=4)		p	
	Pre-test	Post-test	Pre-test	Post-test	<i>study</i>	<i>control</i>
Performance Total Score	$x \pm sd$	$x \pm sd$	$x \pm sd$	$x \pm sd$		
Technical Performance Total Score	3,00±0.00	12.75±1.25	3.00±0.00	3.50±0,57	<0,001*	0.50

*p<0,05

According to the findings obtained from the research, there was a significant difference (p<0.001) in the pre-post test comparison of the study group's oi tsuki chudan technique performance. At the same time, there was no significant difference (p=0.500) in the pre-post test comparison of the control group's oi tsuki chudan technique performance.

Table 2. Analysis of Oi Tsuki Chudan Technique Performance Pre-Test and Post-Test Values of the Study and Control Groups

OiTsuki Chudan Technical	Pre-Test		Post-Test		p	
	Pre-Test (n=4)		Post-Test (n=4)			
Performance Total Score	Study Group	Control Group	Study Group	Control Group	<i>Pre-test</i>	<i>Post-test</i>
	$x \pm sd$	$x \pm sd$	$x \pm sd$	$x \pm sd$		
Technical Performance Total Score	3.00 ± 0.00	3.00 ± 0.00	12.75 ± 1.25	3.50 ± 0.57	1.000	<0.001*

*p<0,05

While no significant difference was found in the pre-test comparison of the oi tsuki chudan technique performance analysis of the study group and the control group (p=1.000), a significant difference was found in the post-test comparison of the oi tsuki chudan technique performance of the two groups (p<0.001).

Table 3. Analysis of the Study Group Delayed-Onset Muscle Soreness Pre-Post Test and Control Group Delayed-Onset Muscle Soreness Pre-Post Test Values

Delayed-Onset	Study Group		Control Group		p	
	(n= 4)		(n=4)		study	control
Muscle Soreness	Pre-test	Post-test	Pre-test	Post-test		
	$x \pm sd$	$x \pm sd$	$x \pm sd$	$x \pm sd$		
Acute	8.25±0.50	4.25±0.50	8.00±0.81	8.00±0.81	0,002*	1,000
Hour 6	8.75±0.95	3.75±0.50	8.75±0.95	8.25±0.50	0,001*	0,500
Hour 24	7.00±0.81	3.00±0.81	6.50±1.29	6.25±0.95	0,002*	1,000
Hour 48	6.75±0.95	2.75±0.50	6.50±1.29	6.75±1.25	0,002*	1,000

*p<0,05

While a significant difference was observed at all times in the pre-post-test comparison of delayed-onset muscle soreness in the study group ($p<0.002$), no significant difference was observed at any time in the pre-post-test comparison of delayed-onset muscle soreness in the control group.

Table 4. Analysis of Delayed-Onset Muscle Soreness Pre-Test and Post-Test Values of the Study and Control Groups

Delayed-Onset	Pre-test		Post-test		p	
	(n= 4)		(n=4)		Pre-test	Post-test
Muscle Soreness	Study Group	Control Group	Study Group	Control Group		
	$x \pm sd$	$x \pm sd$	$x \pm sd$	$x \pm sd$		
Acute	8.25±0.50	8.00±0.81	4.25±0.50	8.00±0.81	0,620	<0,001*
Hour 6	8.75±0.95	8.75±0.95	3.75±0.50	8.25±0.50	1,000	<0,001*
Hour 24	7.00±0.81	6.50±1.29	3.00±0.81	6.25±0.95	0,537	0,002*
Hour 48	6.75±0.95	6.50±1.29	2.75±0.50	6.75±1.25	0,766	0,001*

*p<0,05

While there was no significant difference between the study and control groups in the pretest comparison of delayed-onset muscle soreness, a significant difference was found in favor of the study group at all times in the post-test comparison of delayed-onset muscle soreness of the two groups ($p<0.002$).

DISCUSSION AND CONCLUSION

This study obtained significant results with PNF stretching exercises on visually impaired karate players' oi tsuki technique performance. However, when the effects of PNF stretching exercises on delayed-onset muscle soreness were examined, significant results were obtained in the experimental group.

In a meta-analysis study examined 16 studies on individuals with chronic back pain, which supports our study; it was stated that PNF stretching exercises reduced muscle pain in individuals with chronic back pain (Arcanjo et al., 2022).

Ilan and his colleagues (2020) examined the effects of 3-week PNF stretching exercises on volleyball players' agility performance. As a result of the research, they were found that athletes in the PNF stretching group improved their agility performance more than athletes in the static stretching group (Ilan et al., 2020).

In the PNF method, muscle and joint receptors are stimulated by sensory stimuli to elicit movement. Functional patterns of movement are used instead of using muscle groups in the PNF method (Baygutalp, 2010). Use in PNF techniques aims to increase the ability to initiate movement, teach

INVESTIGATION OF THE EFFECT OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION STRETCHING EXERCISES APPLIED WITH KARATE TRAINING

movement, increase strength, increase stability, improve coordination and control, increase endurance, increase joint range of motion, provide relaxation and reduce pain (Koç, 2020; Livanelioğlu and Erden, 1998).

Ulusoy examined the effects of Proprioceptive Neuromuscular Facilitation (PNF) and Pilates exercises on pain, body image, fear avoidance behaviors, endurance, core stability, disability, and balance functions in patients with chronic low back pain in his study in 2020. PNF exercises were applied to the PNF exercise group 5 sessions per week, 20 sessions in total, 30 minutes, and muscle pain was evaluated with a visual analog scale. When the post-treatment results of the patients in the PNF exercise group were examined, it was seen that there was a decrease in pain levels (Ulusoy, 2020).

In their study conducted in 2022, Sohail et al. compared the effects of proprioceptive neuromuscular facilitation (PNF) and static stretching in relieving pain, increasing range of motion, and improving functional disability in runners with calf muscle delayed onset muscle soreness (DOMS). They divided the participants into three groups and applied PNF stretching to one group, static stretching to another group, and did not apply any application to the last group. They concluded that PNF stretching was relatively more effective than static stretching in reducing pain and improving range of motion and lower extremity functional scale scores in runners complaining of calf muscle DOMS (Sohail et al., 2022).

Today, it is widely stated that sportive activities are of great importance for disabled people (Yazıcıoğlu et al., 2020; Sevimay Özer, 2005; Savucu, 2019). To reduce problems such as obstacle perception problems and lack of experience that make it difficult for visually impaired individuals to be independent in social life, there is a need for individually planned different physical activities that support the physical competence of disabled individuals (Suveren-Erdogan & Suveren, 2018; Pekel et al. 2023). When the literature was examined, no studies were found about PNF stretching exercises on visually impaired karate players. In this respect, this study may have the originality of being the first.

As a result of the study, it was observed that PNF stretching exercises and karate training for 12 weeks effectively improved the technical performance of "Oi Tsuki Chudan" and reduced delayed onset muscle soreness (DOMS) in visually impaired individuals. PNF stretching exercises should be included in the karate training processes of visually impaired individuals to improve their technical performance and accelerate recovery.

REFERENCES

- Ai, L., & Hang, X. (2023). Impacts of pnf stretching on joint flexibility in volleyball athletes. *Revista Brasileira de Medicina do Esporte*, 29, e2023_0046.
- Alpay, H. (2016). *Sensei El Kitabı*, Turkey Karate Federation Education Books Series-07. İstanbul: Spor Dünyası Publishing.
- Arcanjo, F. L., Martins, J. V. P., Moté, P., Leporace, G., de Oliveira, D. A., de Sousa, C. S., ... & Gomes-Neto, M. (2022). Proprioceptive neuromuscular facilitation training reduces pain and disability in individuals with chronic low back pain: A systematic review and meta-analysis—complementary Therapies in Clinical Practice, 46, 101505.
- Arovah, N. I., & Putri, D. A. T. (2024). The acute effect of proprioceptive neuromuscular facilitation recovery technique on fatigue in karate athletes. *Science & Sports*.
- Baltacı, G. (2016). *Spor Yaralanmalarında Egzersiz Tedavisi*. IV. Edition, Pelikan Publishing House, Ankara.
- Baygutalp, F. (2010). *Hemiplejik Üst Ekstremitte Rehabilitasyonunda, Konvansiyonel Fizik Tedavi Modaliteleri ve Nöromüsküler Elektriksel Stimülasyon Kombinasyonunun, tek başına Konvansiyonel Fizik Tedavi Modaliteleri ile Karşılaştırılması*. Ataturk University Faculty of Medicine, Department of Physical Medicine and Rehabilitation, Medical Speciality Thesis.
- Bertozzi, F., Zago, M., Ciprandi, D., Galvani, C., & Sforza, C. (2020). Kinematic traits of an elite paralympic karateka: a case study. *The Journal of Sports Medicine and Physical Fitness*, 60(3), 402-406.
- Bilge, M. (2013). *Stretching İlkeleri: Egzersiz Dağarcığı*. Nobel Academic Publication Distribution, Ankara.
- Çalışkan, E., Pehlivan, A., Serap, I., Şenol, D., & Sedat, A. (2010). Goalball sporunun ve hareket eğitiminin görme engelli çocukların fiziksel uygunluk üzerine etkilerinin değerlendirilmesi. *Journal of Physical Education and Sport Sciences*, 8(3).
- Çetintaş, Y., & Yavuz, Ü. (2021). *Karate Do Mücadele Sanatı*. Gökçe Offset Printing, Ankara.

- Di Palma, D., Raiola, G., & Tafuri, D. (2016). Disability and Sport Management: a systematic review of the literature. *Journal of Physical Education and Sport*, 16(3), 785.
- Dilekçi, U. (2021). *Kata Kumite Elit Sporcu Farklılıkları*. Spor Dünyası Publishing, Turkey Karate Federation Education Books Series-08. Spor Dünyası Publishing, Istanbul.
- Ilan, Z. M. C., Barrion, K. J. P., Ebor Jr, R. A., Zara, J. M. G., Magtibay, C. T. L., Contreras, M. A., & Tosoc, R. M. (2020). The effects of proprioceptive neuromuscular facilitation stretching on agility performance among volleyball varsity players. *The Steth*, 14, 1.
- Jimeno, F. S. S. (2020). Karate do inclusivo en la ciudad de barranquilla. *Revista Educación Física, Deporte y Salud*, 3(6), 71-84.
- Koç, S. (2020). *Sanal Gerçeklik Temelli Robotik Rehabilitasyon Programının Ağırlık Aktarımı ve Harekete Katılım Üzerine Etkilerinin İnme Zamanına Göre Karşılaştırılması* (Master's Thesis, İnönü University Institute of Health Sciences, Malatya, Turkey).
- Livanelioğlu, A. & Erden, Z. (1998). *Proprioseptif Nöromuskuler Fasilitasyon Teknikleri*. Aydoğdu Offset, Ankara.
- Özer, D. (2020). *Özel Gereksinimli Öğrenciler İçin Beden Eğitimi ve Spor*. Nobel Academic Publication Distribution, Ankara.
- Pekel, A. Ö., Suveren, C., Arslan, Y., Yavaşoğlu, B., Beykumül, A., Durhan, T. A., & Ceylan, L. (2023). Effect of 6-week karate (kihon) and basic movement exercise on balance performance in visually impaired individuals. *Frontiers in Physiology*, 14.
- Rodríguez, L. A. P., Candeaux, L. E., & Valdés, A. G. (2021). Acciones metodológicas para la inclusión educativa de educandos con discapacidad intelectual mediante el parakarate/Methodological actions for the educational inclusion of students with intellectual disabilities through para-karate. *PODIUM: Revista de Ciencia y Tecnología en la Cultura Física*, 16(1), 4-16.
- Savucu, Y. (2019). Uyarlanmış beden eğitimi ve spor. *International Journal of Sport Exercise and Training Sciences-IJSETS*, 5(4), 192-200.
- Sevimay Özer, D. (2005). *Engelliler için Beden Eğitimi ve Spor*. Nobel Academic Publication Distribution, Ankara.
- Sohail, M. A. A., Tahir, R., Maqbool, A., Hanif, S., & Saeed, O. (2022). Comparing the effectiveness of static stretching and proprioceptive neuromuscular facilitation stretching in treating delayed onset muscle soreness in calf muscles of runners. *Anaesthesia, Pain & Intensive Care*, 26(1), 31-38.
- Suveren-Erdogan, C., & Suveren, S. (2018). Teaching basic posture skills in visually impaired individuals and its implementation under aggravated conditions. *Journal of Education and Learning*, 7(3), 109-116.
- Ulusoy, M. (2020). *Kronik Bel Ağrılı Hastalarda Proprioseptif Nöromusküler Fasilitasyon ve Pilates Egzersizlerinin Ağrı, Vücut İmajı, Korku Kaçınma Davranışları, Kor Stabilite, Yeti Yitimi ve Denge Fonksiyonları Üzerine Olan Etkilerinin Karşılaştırılması* (Master's thesis, Eastern Mediterranean University (EMU), Gazimağusa, North Cyprus).
- Yavaşoğlu, B. & Marangoz, İ. (2023). *Adapted Sport Para-Karate*, p. 272-279, VII-International European Conference on Interdisciplinary Scientific Research March 28-30, 2023 / Frankfurt, Germany.
- Yazıcıoğlu, H., Pekel, A. Ö., Kemiş, O., & İlhan, L. (2020). Görme engelli çocuklar, yaşam kalitesi ve spor. *Aksaray University Journal of Sport and Health Researches- ASUJSHR*.
- Yılmaz, D. S., Mavi Var, S., & Marangoz, I. (2022). Taekwondocularıda Bosu Ball Denge Egzersizleri ve PNF Germe Çalışmasının Dollyo Chagi Tekniğine Etkileri. *Sportmetre Journal of Physical Education and Sport Sciences*, 20(1), 15-25.