TOJRAS The Online Journal of Recreation and Sports 13(2), 2024
ISSN: 2146-9598 Research Article

Investigation of Acute Effects of Using Different Density Foam Roller Models on Hamstring Muscle Stiffness and Flexibility in Professional Soccer Players

Profesyonel Futbolcularda Farklı Yoğunluklardaki Foam Roller Modelleri Kullanımının Hamstring Kas Sertliği ve Esnekliği Üzerine Akut Etkilerinin İncelenmesi

Muhammet Maksut Ağaoğlu[1], Serkan Usgu[2], Berna Canitez Ağaoğlu[3], *Sinan Seyhan[4]

[1]Manisa Provincial Directorate of Youth and Sports, Republic of Turkey Ministry of Youth and Sports, email: muhammeta.oglu@gmail.com, 0009000553823953
[2]Manisa Provincial Directorate of Youth and Sports, Republic of Turkey Ministry of Youth and Sports, email: fztbernacanitez@gmail.com, 0000000284769372
[3]Hasan Kalyoncu University, Faculty of Health Sciences Department of Physiotherapy and Rehabilitation, e-mail: serkan.usgu@hku.edu.tr, 0000000248209490
[4]Celal Bayar University, Faculty of Sport Sciences Manisa, Turkey e-mail: sinan.seyhan@cbu.edu.tr, sinanseyhan@gmail.com, 0000000249797992
* Corresponding author

Abstract: It was aimed to examine the acute effects of the use of foam roller models of different densities on hamstring muscle stiffness and flexibility in professional soccer players. Hamstring muscle's stiffness were evaluated using the Myoton Pro device. The flexybility of the hamstring muscle were evaluated using with the unilateral sit-reach test on 21 male professional soccer players who played in Gaziantep Soccer Club at aged 18-40. Athletes were randomly divided into groups of seven to use soft, medium and hard foam rollers. The athletes applied the method consisting of two sets of one minute on the dominant hamstring muscle. Measurements were made twice, before the application (BA) and after the application (AA). The muscle stiffness measurement of the athletes was (BA) mean of 16.26 N/m and (AA) mean of 16.17 N/m.; flexibility measurement was determined (BA) mean of 28,36 cm and (AA) mean of 31,05 cm. It was found that the mean of pre-test and post-test did not differ statistically for muscle stiffness (p>0,05) according to measurement times, but statistically differed for flexibility (p<0,05). As a result of the two-way ANOVA test It was determined that there was no statistically significant difference on muscle stiffness and flexibility between foam roller models applied at different intensities (p>0,05). It shows that foam roller application is important for increasing muscle flexibility, but there is no difference between foam roller models applied at different intensities in terms of removing muscle stiffness and increasing flexibility.

Keywords: Foam rollers, muscle stiffness, soccer, flexibility.

Özet: *Profesyonel futbolcularda farklı yoğunluklardaki foam roller modelleri kullanımının hamstring kas sertliği ve esnekliği üzerine akut etkilerinin incelenmesi amaçlanmıştır. Gaziantep Futbol Kulübünde oynayan 18-40 yaş aralığındaki 21 erkek profesyonel futbolcuya, Myoton Pro cihazı kullanılarak hamstring kas sertliği ve unilateral otur- uzan testi ile hamstring kasının esnekliği değerlendirildi. Sporcular yumuşak, orta ve sert köpüklü ruloları (foam roller) kullanacak şekilde rastgele yedi kişilik gruplara ayrıldı. Sporcular birer dakikalık iki setten oluşan yöntemi dominant hamstring kasına uyguladılar. Ölçümler uygulama öncesi (UÖ) ve uygulama sonrası (US) olmak üzere iki kez yapıldı. Sporcuların kas sertliği ölçümü (UÖ) ortalaması 16,26 N/m, (US) ortalaması 16,17 N/m olarak; esneklik ölçümü (UÖ) ortalaması 28,36 cm, (US) ortalaması 31,05 cm olarak belirlendi. Ön test ve son test ortalama ölçüm zamanlarına göre kas sertliği için istatistiksel farklılık göstermediği (p>0,05) fakat esneklik için istatistiksel açıdan farklılık gösterdiği (p<0,05) belirlendi. İki yönlü ANOVA testi sonucunda farklı yoğunluklarda uygulanan foam roller modelleri arasında kas sertliği ve esneklik üzerine istatistiksel açıdan anlamlı farklılık olmadığı tespit edildi (p> 0,05). Kas esnekliğinin artırılması için foam roller uygulamasının önemli olduğunu ancak farklı yoğunluklarda uygulanan foam roller modelleri arasında kas sertliğinin giderilmesi ve esnekliğin artırılması açısından fark olmadığını göstermektedir.*

Anahtar Kelimeler: *Foam roller, kas sertliği, futbol, esneklik.*

Received: 15.03.2024 / Accepted: 25.04.2024 / Published: 30.04.2024

https://doi.org/10.22282/tojras.1453141

Citation: *Ağaoğlu, M.M., Usgu, S., Canıtez Ağaoğlu, B., & Seyhan, S.. (2024). Investigation of Acute Effects of Using Different Density Foam Roller Models on Hamstring Muscle Stiffness and Flexibility in Professional Soccer Players, The Online Journal of Recreation and Sports (TOJRAS), 13(2), 199-204.*

INTRODUCTION

Hamstring is a muscle group located in the lower extremity and whose flexibility is often evaluated (1). The flexibility of the hamstring muscle is a very important component in sports in order to perform functional movements efficiently (2). Reduced flexibility of the knee and hip flexor muscles is an important risk factor for hamstring injuries. Decreased hamstring flexibility in soccer players as well as athletes in different branches (3), It has been emphasized that it negatively affects basic performance parameters such as speed (4), explosive power and agility, and that hamstring muscle flexibility is extremely important to increase all these performance characteristics (5). Muscle stiffness is a biomechanical property of the muscle, and in healthy individuals (6), muscle stiffness is primarily a function of both active and passive muscle tension or muscle strength (7). The hamstring muscle group is an important anatomical structure for people's performance (8). Muscle stiffness in the hamstrings can lead to muscle injuries, patellar tendinopathy, patellafemoral pain, and major muscle imbalances that predispose to the development of lower back pain (3).

Muscle injuries are causally related to impaired joint flexibility. Muscle stiffness is one of the main components of joint flexibility (8–11). Tension of the body's soft tissue structures, joint capsules, muscles, and fascia, can affect flexibility. Myofascia surrounding the muscle is connective tissue that can affect flexibility and reduce muscle strength and endurance if injured, inactive or inflamed (12). Such applications are performed by a specialist to solve the existing problem of movement restrictions due to fascia.

Recently, individuals have been using foam roller material to perform fascial releases on their own without the help of a therapist. Foam roller is used as an exercise and massage device. Although the material used in the device is a type of foam, it is polypropylene rolls available in various densities. These rollers use the same treatment mechanism as traditional myofascial release (13,14). Foam Rollers are applications that are applied to a certain part of the body to increase flexibility and relaxation, and by putting pressure on the tissue there, blood circulation occurs, thus increasing the temperature in the fascia. Rolling applications allow removing knots in the fascia layers and regaining the elasticity of the tissues in that areaApplications made with foam roller it has been proven in many studies that it has effects such as increasing flexibility and joint movement and ensuring fascia mobility (15–17). Various foam roller models are available that differ in density, shape and surface texture. These differences may lead to

different effects on myofascial tissue during treatment. For example a hard density foam roller can provide more effective pressure to the tissue than a softer density foam roller model (18).

As a result of the literature research, it was concluded that the therapeutic effects of foam roller models of different densities should be investigated in more detail, as there have not been sufficient studies on the use of foam rollers in the soccer branch. It is thought that by understanding the effects of the use of foam roller models of different densities on professional soccer players and ensuring the selection with the right density will be safer and more effective in terms of performance. The unknown therapeutic effects of foam roller models of various densities create a knowledge gap with potential implications for clinical practice. There is no evidence-based recommendation for people about what density of foam roller model they should use, and this choice depends on personal preference.

Our hypothesis for our research is that the use of foam roller models with different intensities may have different effects on hamstring muscle stiffness and flexibility in professional football players. In the study planned to be carried out for this purpose; It was aimed to examine the acute effects of using foam roller models of different densities on hamstring muscle stiffness and flexibility in professional soccer players.

METHODS

Research Model: Foam roller models of different intensities were applied to the participants who were suitable for the previously determined study and their effects on the dependent variable were examined.

Purpose of the Research: This study was conducted to understand the effects of the use of foam roller models on professional soccer players and to ensure the selection, with the right density will be safer and more effective in terms of performance.

Research Group: The research was conducted at Gaziantep Soccer Club. The research started with data scanning in October 2021 and ended with the thesis defense in July 2023. The population of the research consisted of soccer players playing in Gaziantep Soccer Club, and the sample consisted of soccer players who met the inclusion criteria.

21 professional soccer players, aged between 18 and 40 and without a history of orthopedic injury in the lower extremities in the last 12 months, were included in the study. A descriptive evaluation form containing the demographic information of the athletes was used as a data collection tool. Individuals who agreed to participate in the study signed an informed consent form. Athletes were informed that they should inform the researcher in case of any side effects during the evaluations and application. Evaluations took an average of 20 minutes.

Data Collection: Demographic and anthropometric measurements (gender, age, height, weight, body mass index [BMI]) of the participants were recorded. Evaluations were made on the dominant side and in a randomized manner. Necessary rest periods were given between tests. This cycle was repeated for one minute. After a 30-second rest break, the procedure was repeated for another minute. The procedure consisted of two sets of one minute in total and a 30-second rest period between sets (15). To ensure the accuracy of the measurements, participants were instructed to avoid strenuous activity for five hours before the test and not to take any medication that would interfere with the test. Evaluations were made before and after the application (within 10 minutes) (19).

Myoton PRO (Myoton AS, Estonia) device was used for hamstring muscle stiffness evaluation. This device measures the texture properties of naturally damped oscillations produced by a brief (15 ms) mechanical touch to the skin surface. To determine the tone and viscosity of the muscle, it was applied to the hamstring muscle in the prone position with the Myoton Pro device at room temperature. Participants were instructed to refrain from exercise on the day of administration. Participants were positioned face down and at rest on a flat practice bed. Participants were asked to keep their leg completely relaxed throughout the measurement in order not to affect tissue stiffness. The midpoint of the muscle bulge and the center of the tendon were determined to be 12.8 cm below the sacroiliac joint, on the line between the sacroiliac joint and the lateral epicondyle. All measurements were made by holding the device perpendicular to the skin in the relevant area to reduce the effect of gravity on tissue properties. Measurements were repeated three times with 15-second intervals and the average value of all measurements was calculated (20).

The flexibility of the hamstring muscle was determined using the soccer players' unilateral sit-reach test (backsaver sit-reach test). During the test, the soccer players' shoes were removed and their dominant legs were placed on the sit-and-reach flexibility test mechanism. The other leg was positioned at 90° flexion. While the measurement was made twice, they were asked to reach as far as the last point they could reach without bending their knees, leaning their bodies forward, slowly pushing the ruler forward and waiting without moving for at least two seconds (sec.) at the last point. The highest value obtained was recorded in centimeters (cm) and used for analysis (12). Athletes were divided into three groups using randomization. Soft density, medium density and hard density foam roller groups each consisted of seven athletes. The three foam rollers of different densities we used in the study are manufactured by TriggerPoint™ and all have the same multi-level GRID surface pattern and diameter (14 cm). This allowed direct comparison. The difference between the three types of foam rollers is density. Soft density (SD) core foam roller (silver); Made from solid EVA foam; Medium density (MD) grid foam roller (orange); It is wrapped in moderately tough EVA foam around a hard, hollow core. Hard density (HD) grid x foam roller (black); It's wrapped with lots of sturdy EVA foam around a hard, hollow core (19). During the measurements, the soccer players were asked to roll the foam roller from the ischial tuberosity to the fossa poplitealis on the dominant leg. Persons; their hands were placed on the floor while in a tall sitting position. Hands were not allowed to move during the rolling motion. Movement was achieved by sliding the body back and forth. The non-dominant leg served as a stabilizer. Participants were instructed to maintain their maximum weight on the dominant leg (14). When the foam

roller reached the fossa poplitealis, participants were instructed to quickly return the foam roller to the starting position. This cycle was repeated for one minute. After a 30-second rest break, the procedure was repeated for another minute. The procedure consisted of two sets of one minute in total and a 30-second rest period between sets (15).

Analysis of Data: SPSS 21 was used to analyze the data obtained. Mean, standard deviation, percentage and frequency were used in descriptive statistics of demographic variables. Whether the data showed normal distribution was tested with the Shapiro Wilk test. Two-way repeated measures analysis of variance (Two-way Repeated Measures ANOVA) was used to analyze normally distributed data. The confidence interval was chosen as 95% and values below $p < 0.05$ were considered statistically significant.

RESULTS

21 male professional soccer players participated in the study. The average age was calculated as 18,19±0,402 years, the average height as 180,48±6,258 cm, the average body weight as 70,71±7,823 kg, and the average BMI as 21,66±1,65 kg/m2.

The athletes were divided into three groups using randomization: seven with HD foam rollers, seven with MD foam rollers and seven with SD foam rollers. The descriptive characteristics of the athletes are shown in table 1.

Table 1. Descriptive Characteristics

Descriptive Characteristics	Mean±Std
Age (years)	18,19±0,402
Height (cm)	180,48±6,258
Weight (kg)	70,71±7,823
BMI (kg/m2)	21,66±1,65

(kg: kilogram, m: metres, cm: centimeter, std: standard deviation, bmi: body mass index)

Table 2. Muscle Stiffness and Flexibility (Before and After Application) Evaluation Findings

Muscle Stiffness and Flexibility	Meant±Std
Muscle Stiffness (BA) (N/m)	16,26±1,08
Muscle Stiffness (AA) (N/m)	16,16±0,75
Elasticity (BA) (cm)	28,35±8
Elasticity (AA) (cm)	31,04±8,15

(BA: before application, AA: after application, N: newton, m: metres, cm: centimeter, Std: standard deviation)

When Table 2 was examined, it was determined that the muscle stiffness pre-test and post-test averages of foam roller models applied at different intensities did not differ statistically according to measurement times ($p > 0.05$). Additionally, it was determined that there was no statistically significant difference in muscle stiffness between foam roller models applied at different intensities ($p > 0.05$). Moreover, it was observed that the group and time interactions of acute foam roller applications of different intensities were not significant. This result shows that there is no difference between foam roller models applied to relieve muscle stiffness at different intensities after exercise.

Muscle stiffness and flexibility values before and after application were determined using the relationship sample t-test. When the muscle stiffness and flexibility evaluations of the soccer players in the study were examined; The average muscle tone measurement of soccer players was determined as 16,26 before the application and 16,16 after the application. The flexibility measurement average before the application was 28,35 and the average after the application was 31,04. The evaluation findings of the soccer players' muscle stiffness and flexibility values before and after the application are shown in table 2.

Table 3. Muscle Stiffness and Flexibility Change Findings

Muscle Stiffness and Flexibility Change	t	p
Muscle Stiffness Change (N/m)	0,76	0,45
Elasticity Change (cm)	-9,49	0,00*

*(N: newton, m: metres, cm: centimeter t: Independent sample t test, *p<0,05 was considered statistically significant)*

According to the results of muscle stiffness and flexibility changes before and after the application, determined using the dependent t-test (parametric), muscle stiffness did not show a significant difference (t = 0,764, p = 0,454), but the flexibility result showed a significant difference (t = -9,493, p). <0,05) and the difference was found to be in favor of the last application.

Table 4. Effect of Foam roller Models of Different Densities on Changes in Muscle Stiffness and Flexibility

Muscle Stiffness and Flexibility Change	Foam roller Model	Mean±Std
Muscle Stiffness (N/m)	(HD) Black (n:7)	-0,25±0,52
	(MD) Orange (n:7)	0,01±0,23
	(SD) Silver (n:7)	-0,15±0,86
Elasticity (cm)	(HD) Black (n:7)	3,07±0,33
	(MD) Orange (n:7)	2,42±0,72
	(Silver) (n:7)	2,57±0,35

(n: newton, m: metres, cm: centimeter, std: standard deviation, HD: hard density, MD: medium density, SD: soft density)

The effect of foam roller models of different densities on muscle stiffness and flexibility changes in soccer players is shown in Table 4.

Table 5. Muscle Stiffness and Flexibility Change Intergroup Evaluation Findings

Changes in Muscle Stiffness and Flexibility Between Groups	F	p
Muscle Stiffness Change (N/m)	0,425	0,66
Elasticity Change (cm)	0,447	0,647

*N: newton, m: metres, cm: çentilmeler, F: difference between means, *p<0,05 was considered statistically significant)*

As a result of the ANOVA test, it was seen that Foam roller applied at different intensities did not create a significant difference on muscle stiffness change (F = 0,425, p = 0,660) and flexibility change (F = 0,447, p = 0,647) (p>0,05). Muscle stiffness and flexibility change evaluation findings between groups are shown in table 5.

DISCUSSION

The flexibility of the hamstring muscle, which is one of the muscles that tend to shorten the most in the lower extremity, plays a vital role in the efficiency and effectiveness of basic movements (21). Foam rolling is a self-administered myofascial release technique. The pressure on the fascia from rolling allows the fascia to soften and lengthen, allowing the muscle to be stretched more widely (22). Applications made with foam roller; It has been proven in many studies that it

has effects such as increasing flexibility and joint movement and ensuring fascia mobility (17). In the literature, there is no consensus on the optimum protocol for foam roller application to produce the most effective results. There is no clarity regarding the effect of foam roller models of different densities on performance and more research is needed (19). In our study; It was aimed to examine the acute effects of using foam roller models of different densities on hamstring muscle stiffness and flexibility in professional soccer players. According to the results obtained when the average muscle stiffness measurement of soccer players before the application 16.26 N/m and the average after the application 16.16 N/m.. The average flexibility measurement before the application 28.35 cm and the average after the application 31.04 cm. According to the results of muscle stiffness and flexibility change before and after the application, it was found that muscle stiffness did not differ significantly, but the flexibility result showed a significant difference and the difference was in favor of the last application ($p < 0,05$). It was observed that Foam roller applied at different intensities did not create a significant difference in muscle stiffness change and flexibility change. However, it is important to note that not every participant practiced with all intensities of foam roller models in the current study body.

In the study conducted, who examined the effect of foam roller applied in different periods and sets on hamstring muscle flexibility, it was found that while a significant increase was observed in (2 sets and 10-second) muscle flexibility evaluated with the sit-and-reach test in all application groups (12). In our study, foam roller application was applied to the athletes in 2 sets and 10-second cycles. According to the findings of the study conducted (23), it was observed that the range of motion increased significantly in both static stretching and foam roller groups, semitendinosus muscle stiffness decreased significantly, but there was no significant change in biceps femoris muscle stiffness. When the muscle stiffness change in the foam roller applied group was examined; A significant decrease was detected, ranging from 6,7% N/m in semitendinosus to 6,5% N/m in semimembronosus. In the biceps femoris, the decrease was found to be 1% N/m and not significant. Unlike our study, while a change in muscle stiffness was observed, this change is thought to be due to the positions of the muscles examined separately in the three parts of the hamstring and their different fascicle structures. When the location of the muscles is compared, semitendinosus and semimembronosus are located on the medial side of the rear thigh and biceps femoris is located on the lateral side of the thigh (24). Due to the possible slight inward rotation of the leg for trunk stability during the foam roller rolling procedure in the hamstring muscle, the semitendinosus and semimembronosus muscles may receive more intense stimulation than the biceps femoris muscle located laterally. Another possible explanation for the differences in stiffness changes could be the different lengths and orientations of the fascicles in the three muscles measured (25).

In their study conducted (19), who obtained similar results to the results of our study. They found the acute effects of foam rollers of three different intensity types applied to the quadriceps muscle on passive knee flexion ROM and pressure pain thresholds (PPT) has been examined. As a result of the research; In the intra-group comparison, significant increases were found in favor of the post-test for ROM and PPT in all applications applied with foam roller at three different densities. However, in comparisons between groups, it was revealed that the foam roller models showed similar effects and there was no statistically significant difference between them (19). In the study conducted (26), who investigated the effects of foam roller models of different intensities, a significant increase in hamstring flexibility was found in all groups immediately after five-minute foam roller application to the hamstring muscles ($p < 0,05$). Theorized, the local pressure of the foam roller may influence the viscoelastic properties of the myofascia, resulting in greater stretching. Studies have shown that the application of foam roller sharply reduces arterial stiffness and improves vascular endothelial function, resulting in a tissue relaxation effect resulting in a greater elasticity score (27,28). It may also cause ROM changes as a result of a combination of other mechanisms (15,18,29,30). The most common theory used to explain increased ROM with myofascial release is the thixotropic property of fascia (16). This theory explains that when fascia is not subjected to any pressure, it is more viscous and takes on a stiffer form, which can restrict movement. Theories in the aforementioned study include changes in the thixotropic property of myofascia, increases in intramuscular temperature and blood flow, changes in muscle spindle length, stretch perception, physical breakdown of scar tissue, and remobilization of myofascia. Many of these factors are impossible to measure or quantify.

It is clear that there are differences in the results found between studies. The reasons for this difference are; Application time of myofascial relaxation methods, where the myofascial areas are applied and the intensity of application, that is, its rhythm, the pressure in the application, the hardness level, size and surface shape of the foam roller used in myofascial application (12,14). However, no matter how cautiously one approaches the results, it can be said that one should trust studies that contain findings that the application of myofascial release methods such as foam roller can accelerate blood flow in the muscle, reduce muscle contraction, and widen the ROM (17).

Conclusions: According to the results obtained from our study; It was found that the hamstring muscle stiffness measured after the application did not show a significant difference compared to before the application. However the hamstring flexibility increased after the foam roller application in all groups and the increase showed a significant difference ($p < 0,05$). No significant advantage was found between foam roller models of different densities over each other. Our work; It represents a small population of professional soccer players and male gender. Future studies can be implemented in a larger population with a larger number of participants by completing a power analysis calculation to determine the optimal number of participants. In this study, the effects of flexibility and muscle stiffness were determined by (acute) measurements made immediately after the application. Therefore, the long-term effects of varying foam roller densities are unknown. It is stated in the literature that the permanent physiological effects of foam roller applications last between one and three weeks and that more research is needed due to inconsistent results (31). For

these reasons, it may be wrong to definitively confirm the findings we have obtained within the scope of the research. In order to make a definitive statement on the subject, longer-term studies with more participants may be needed.

Scientific studies on the subject; It points to the positive effects of foam roller application before and after training. Applications made with foam rollers before starting the warm-up exercise before the training; It can be said that it can help shorten the warm-up time, help the muscles adapt more easily to the training to be done, and thus reduce the risk of injury.

Ethics Committee: *During the research process in this article, the journal's writing rules, publication principles, research and publication ethics rules, and journal ethics rules were followed. The responsibility for any violations that may arise regarding the article belongs to the author. Manisa Celal Bayar University Faculty of Medicine, Health Sciences Ethics Committee approved that it complies with the provisions of publication ethics with the decision dated 29.12.2021 and numbered 20.478.486/1110.*

Conflict of Interest: *There is no personal or financial conflict of interest between the authors in this study.*

References

1. Knapik JJ. The importance of physical fitness for injury prevention: part 1. J Spec Oper Med. 2015;15(1):123–7.
2. Hoff J, Helgerud J. Endurance and strength training for soccer players: physiological considerations. Sports medicine. 2004;34:165–80.
3. Morin JB, Gimenez P, Edouard P, Arnal P, Jiménez-Reyes P, Samozino P, et al. Sprint acceleration mechanics: the major role of hamstrings in horizontal force production. Front Physiol. 2015;6:169279.
4. Seyhan S. Comparison of Physical and Physiological Performance Features of Parkour and Gymnastics Athletes. Journal of Education and Learning. 2019;8(2):111–6.
5. García-Pinillos F, Ruiz-Ariza A, Moreno del Castillo R, Latorre-Román PÁ. Impact of limited hamstring flexibility on vertical jump, kicking speed, sprint, and agility in young football players. J Sports Sci. 2015;33(12):1293–7.
6. Hug F, Tucker K, Gennisson JL, Tanter M, Nordez A. Elastography for muscle biomechanics: toward the estimation of individual muscle force. Exerc Sport Sci Rev. 2015;43(3):125–33.
7. Klauser AS, Miyamoto H, Bellmann-Weiler R, Feuchtner GM, Wick MC, Jaschke WR. Sonoelastography: musculoskeletal applications. Radiology. 2014;272(3):622–33.
8. Miyamoto N, Hirata K, Kanehisa H. Effects of hamstring stretching on passive muscle stiffness vary between hip flexion and knee extension maneuvers. Scand J Med Sci Sports. 2017;27(1):99–106.
9. Magnusson SP, Simonsen EB, Aagaard P, Boesen J, Johannsen F, Kjaer M. Determinants of musculoskeletal flexibility: viscoelastic properties, cross-sectional area, EMG and stretch tolerance. Scand J Med Sci Sports. 1997;7(4):195–202.
10. Watsford ML, Murphy AJ, McLachlan KA, Bryant AL, Cameron ML, Crossley KM, et al. A prospective study of the relationship between lower body stiffness and hamstring injury in professional Australian rules footballers. Am J Sports Med. 2010;38(10):2058–64.
11. Witvrouw E, Danneels L, Asselman P, D'Have T, Cambier D. Muscle flexibility as a risk factor for developing muscle injuries in male professional soccer players: a prospective study. Am J Sports Med. 2003;31(1):41–6.
12. Sullivan KM, Silvey DBJ, Button DC, Behm DG. Roller-massager application to the hamstrings increases sit-and-reach range of motion within five to ten seconds without performance impairments. Int J Sports Phys Ther. 2013;8(3):228.
13. Freiwald J, Baumgart C, Kühnemann M, Hoppe MW. Foam-rolling in sport and therapy–potential benefits and risks: part 1–definitions, anatomy, physiology, and biomechanics. Sports Orthopaedics and Traumatology. 2016;32(3):258–66.
14. Couture G, Karlik D, Glass SC, Hatzel BM. The effect of foam rolling duration on hamstring range of motion. Open Orthop J. 2015;9:450.
15. MacDonald GZ, Penney MDH, Mullaley ME, Cuconato AL, Drake CDJ, Behm DG, et al. An acute bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force. The Journal of Strength & Conditioning Research. 2013;27(3):812–21.
16. Sefton J. Myofascial release for athletic trainers, part I: Theory and session guidelines. International Journal of Athletic Therapy and Training. 2004;9(1):48–9.
17. Fairall RR, Cabell L, Boergers RJ, Battaglia F. Acute effects of self-myofascial release and stretching in overhead athletes with GIRD. J Bodyw Mov Ther. 2017;21(3):648–52.
18. Cheatham SW, Kolber MJ, Cain M, Lee M. The effects of self-myofascial release using a foam roll or roller massager on joint range of motion, muscle recovery, and performance: a systematic review. Int J Sports Phys Ther. 2015;10(6):827.
19. Cheatham SW, Stull KR. Comparison of three different density type foam rollers on knee range of motion and pressure pain threshold: a randomized controlled trial. Int J Sports Phys Ther. 2018;13(3):474.
20. van der Made AD, Wieldraaijer T, Kerkhoffs GM, Kleipool RP, Engebretsen L, Van Dijk CN, et al. The hamstring muscle complex. Knee Surgery, Sports Traumatology, Arthroscopy. 2015;23:2115–22.
21. Gajdosik RL. Effects of static stretching on the maximal length and resistance to passive stretch of short hamstring muscles. Journal of orthopaedic & sports physical therapy. 1991;14(6):250–5.
22. Barnes MF. The basic science of myofascial release: morphologic change in connective tissue. J Bodyw Mov Ther. 1997;1(4):231–8.
23. Reiner MM, Tilp M, Guilhem G, Morales-Artacho A, Konrad A. Comparison of a single vibration foam rolling and static stretching exercise on the muscle

function and mechanical properties of the hamstring muscles. J Sports Sci Med. 2022;21(2):287.
24. Balius R, Pedret C, Iriarte I, Sáiz R, Cerezal L. Sonographic landmarks in hamstring muscles. Skeletal Radiol. 2019;48:1675–83.
25. Kellis E, Galanis N, Kapetanos G, Natsis K. Architectural differences between the hamstring muscles. Journal of Electromyography and Kinesiology. 2012;22(4):520–6.
26. Rhodes D, Crowie S, Alexander J. Acute effects of varying densities of foam roller on hamstring flexibility and eccentric strength. Int J Ther Rehabil. 2022;29(3):1–12.
27. Krause F, Wilke J, Niederer D, Vogt L, Banzer W. Acute effects of foam rolling on passive tissue stiffness and fascial sliding: study protocol for a randomized controlled trial. Trials. 2017;18:1–6.
28. Okamoto T, Masuhara M, Ikuta K. Acute effects of self-myofascial release using a foam roller on arterial function. The Journal of Strength & Conditioning Research. 2014;28(1):69–73.
29. Mohr AR, Long BC, Goad CL. Effect of foam rolling and static stretching on passive hip-flexion range of motion. J Sport Rehabil. 2014;23(4):296–9.
30. Bradbury-Squires DJ, Noftall JC, Sullivan KM, Behm DG, Power KE, Button DC. Roller-massager application to the quadriceps and knee-joint range of motion and neuromuscular efficiency during a lunge. J Athl Train. 2015;50(2):133–40.
31. Macgregor LJ, Fairweather MM, Bennett RM, Hunter AM. The effect of foam rolling for three consecutive days on muscular efficiency and range of motion. Sports medicine-open. 2018;4:1–9.

GENİŞLETİLMİŞ ÖZET

Çalışmanın Amacı: Farklı yoğunluklardaki foam roller modellerinin kullanımının profesyonel futbolcular üzerindeki etkilerini anlamak ve doğru foam roller seçimini sağlayarak, doğru yoğunluktaki foam roller kullanımının performans açısından daha güvenli ve etkili olacağı düşünülmektedir. Profesyonel futbolcularda farklı yoğunluklardaki foam roller modelleri kullanımının hamstring kas sertliği ve esnekliği üzerine akut etkilerinin incelenmesi amaçlanmıştır.

Araştırma Problemleri: Kas esnekliğinin artırılması için foam roller uygulaması gerçekten sporcu performansı açısından önemli midir? Ayrıca farklı yoğunluğa sahip foam roller modellerinin kas sertlği ve esneklik ile ilişkisi var mıdır?

Literatur Araştırması: Kas yaralanmaları eklem esnekliğinin bozulması ile nedensel olarak ilişkilidir (10,11). Kas sertliği, eklem esnekliğinin ana bileşenlerinden biridir (8,9). Vücuttaki yumuşak doku yapılarının eklem kapsüllerinin, kasların ve fasyaların gerginliği esnekliği etkileyebilir. Kası çevreleyen miyofasya, esnekliği etkileyebilen ve yaralı, inaktif veya iltihaplı olması durumunda kas kuvvetini ve enduransını azaltabilen bağ dokusudur (12). Fasya kısıtlamalarının etkilerini hafifletmek için bir dizi miyofasyal salım tekniği kullanılmaktadır. Bu teknikler normal olarak bir terapist tarafından manuel olarak gerçekleştirilir. Son zamanlarda bireyler bir terapistin yardımı olmadan kendi kendilerine fasyal salınımlarını yapabilmeleri için foam roller (köpük yuvarlama) materyalini kullanmaktadır. Foam roller, bir egzersiz ve masaj cihazı olarak kullanılmaktadır. Cihazda kullanılan materyal, bir çeşit köpük olmakla birlikte, çeşitli yoğunluklarda tipleri bulunan polipropilen yapıdaki rulolardır. Bu rulolar geleneksel miyofasyal salınımla aynı tedavi mekanizmasını kullanır. Foam roller, bir kişinin kendi kendine masaj olarak belirli bir vücut bölgesinin esnekliğini arttırmak için vücut ağırlığını kullanarak basınç uyguladığı yöntemdir. Yuvarlanma sırasında, yumuşak dokunun üzerine doğrudan ve süpürme basıncının uygulandığı, fasyanın gerilmesine ve esnekliğin artmasına neden olduğu varsayılmaktadır. Yuvarlanma hareketi sırasında da sürtünme oluşur ve bu sürtünme fasyanın sıcaklığının artmasına ve muhtemelen daha akışkan benzeri bir duruma dönüşmesine neden olur (13,14).

Yöntem: Gaziantep Futbol Kulübünde oynayan 18-40 yaş aralığında ki 21 erkek profesyonel futbolcuya, Myoton Pro cihazı kullanılarak hamstring kas sertliği ve unilateral otur-uzan testi ile hamstring kasının esnekliği değerlendirildi. Üç tip foam roller arasındaki fark yoğunluktur. Yumuşak yoğunluklu CORE foam roller (gümüş); katı EVA köpüğünden yapılmıştır. Orta yoğunluklu GRID foam roller (turuncu); Sert, içi boş bir çekirdeğe orta derecede sağlam EVA köpüğü ile sert yoğunluklu GRID foam Roller ise (siyah); sert, içi boş çekirdeğe birçok sağlam EVA köpüğü ile sarılmıştır. Sporcular randomize olarak yedişer kişiden oluşan yumuşak, orta ve sert yoğunluklu foam roller kullanılmak üzere gruplara ayrılmıştır. Sporcular dominant taraf hamstring kasında birer dakikalık iki setten oluşan yöntemi uygulamıştır. Ölçümler uygulama öncesi [UÖ] ve uygulama sonrası [US] olmak üzere iki kez yapılmıştır.

Sonuç ve Değerlendirme: Futbolcuların kas sertliği ölçümü UÖ ortalaması 16,26 N/m ve US ortalaması 16,17 N/m olarak belirlendi. Esneklik ölçümü UÖ ortalaması 28,36 cm ve US ortalaması 31,05 cm bulundu. Ön test ve son test ortalama ölçüm zamanlarına göre kas sertliği için istatistiksel farklılık göstermediği ($p>0,05$) fakat esneklik için istatistiksel açıdan farklılık gösterdiği ($p<0,05$) belirlendi. İki yönlü ANOVA testi sonucunda; farklı yoğunluklarda uygulanan foam roller modelleri arasında kas sertliği ve esneklik üzerine istatistiksel açıdan anlamlı farklılık olmadığı tespit edildi ($p> 0,05$). Çalışmamız; profesyonel futbolcular ve erkek cinsiyetten oluşan küçük bir popülasyonu temsil etmektedir. Gelecekteki çalışmalar, en uygun katılımcı sayısını belirlemek için bir güç analizi hesaplaması tamamlanarak daha fazla katılımcı sayısı içeren daha geniş bir popülasyonda uygulanabilir. Bu çalışmada esneklik ve kas sertliği etkileri uygulamadan hemen sonra yapılan (akut) ölçümler ile belirlenmiştir. Bu nedenle, değişen foam roller yoğunluklarının uzun süreli etkileri bilinmemektedir. Kas esnekliğinin artırılması için foam roller uygulamasının önemli olduğunu ancak farklı yoğunluklarda uygulanan foam roller modelleri arasında kas sertliğinin giderilmesi ve esnekliğin artırılması açısından fark olmadığını göstermektedir.