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Acute effects of different foam roller types on isokinetic strength in female basketball players

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Abstract

Foam rolling is frequently used in warm-up routines by athletes, yet the effects of different roller types on muscle strength remain unclear. Therefore, this study aimed to examine the acute effects of self-myofascial release using different foam roller textures on knee isokinetic strength in female basketball players. Fourteen basketball players (age: 20.5±1.7 years; training experience: 10.9±3.1 years, height: 175.1±8.7 cm, body mass: 66.0±7.3 kg) participated in a randomized crossover design consisting of three sessions: baseline, superficial foam rolling, and deep tissue foam rolling. Following a standardized 10-min warm-up, foam rolling was applied for 90 s each to the hamstrings and quadriceps muscles. Isokinetic strength of both legs was assessed at an angular velocity of $60°\cdot s^{-1}$ using a dynamometer. Hamstrings peak torque did not differ significantly among protocols. However, quadriceps peak torque of the dominant leg was significantly reduced after superficial foam rolling ($p=.014$; $\eta^2_p=.311$). Conversely, hamstring power in the non-dominant leg increased significantly after both foam rolling intervention ($p<.05$). Foam rolling produced selective and limb-specific effects on knee isokinetic strength. Deep tissue foam rolling may safely enhance readiness without impairing strength, whereas superficial foam rolling might temporarily decrease quadriceps torque.

Introduction

Recently, athletes have been using manual therapy or self-myofascial release (SMR) techniques (França et al., 2023; Hendricks et al., 2020) as a sport-specific warm-up tool to enhance their athletic performance (Kurt et al., 2023). SMR is a technique based on applying pressure to specific areas of the body using one's own body weight (Rivera et al., 2023) and is mostly performed by rolling on the floor with a foam roller (FR), which can have different textures, sizes, and even vibrating features (Martínez-Aranda et al., 2024). FR type is a factor that potentially affects the effectiveness of the SMR procedure (Adamczyk et al., 2020), and increased stiffness and irregular structure (grid surface) contribute to increased pressure on the tissue where FR is applied (Monteiro & Neto, 2016). It has been suggested that the pressure applied to tissues during SMR can also cause pain (Debski et al., 2019) and that hard-intensity tools may have a stronger effect than softer-intensity tools (Curran et al., 2008). In SMR practice, there are various apparatus (massage sticks, massage guns, FRs, FRs with vibration mechanisms, lacrosse balls, tennis balls, etc.) available on the market in different surfaces, shapes, sizes, and hardnesses (Behara & Jacobson, 2017; Debski et al., 2019; Phillips et al., 2021; Stroiney et al., 2020). The variety of available FR types makes the selection of the optimal tool challenging (Michalak et al., 2024).

Foam rolling, a warm-up strategy, can reduce muscle stiffness and increase range of motion (RoM) and should be used in conjunction with dynamic stretching and active warm-up before a training session (Hendricks et al., 2020). In basketball, FRs for SMR are widely used by players during training and competition warm-ups. In basketball, athletes cover approximately 4.500-5.000 meters during training or competition with a variety of multi-directional movements such as running, dribbling, change-of-direction at varying speeds, and jumping (Torres-Unda et al., 2016). A basketball player requires the production of substantial amounts of strength and power to change direction, accelerate, decelerate, and stop while covering these distances. Therefore, in basketball, the importance of

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strength and power for on-court success cannot be ignored (Wen et al., 2018). In this context, due to the association of myofascial release with performance enhancement, significant increases have been observed in the use of FRs prior to athletic performance in recent years (Skinner et al., 2020).

Functional integration capacity is already clearly evident in the scientific literature on muscular fascia; it enables force transmission that specifically affects muscle tissue (Duarte França et al., 2024; Fede et al., 2022). Furthermore, the fascial system affects approximately 2% of maximum voluntary contraction at rest and approximately 1% of muscle tone (Masi & Hannon, 2008). In addition, it is known that changes in fascial mechanical properties (stiffness, varying thickness) can affect flexibility, muscle contraction, and limit RoM (Bordoni & Zanier, 2015; Wilke et al., 2020). Myofascial release eliminates restrictions within the fascia layers and also causes pressure on the soft tissue to stimulate mechanoreceptors, which can then reduce muscle and fascia tension (Russo et al., 2023). Moreover, a recent meta-analysis reported that foam rolling applied during warm-up does not acutely affect isometric muscle strength, eccentric torque, and rate of force development, but increases knee extensor concentric torque and does not acutely alter myofascial tissue stiffness and isometric muscle strength (Glänzel et al., 2023). However, considering that the outcomes revealed in this analysis may be influenced by various factors such as foam rolling duration, the gender and age of the participant group, and the type of FR, it can be stated that a careful and in-depth analysis is required.

Studies on foam rolling have shown effects on RoM and flexibility (Bradbury-Squires et al., 2015; Jeong et al., 2019; Monteiro et al., 2018, 2019; Sagiroglu et al., 2017; Wilke et al., 2020), muscle strength (Acar et al., 2022; Behara & Jacobson, 2017; Chen et al., 2023; Cornell & Ebersole, 2020; Glänzel et al., 2023; Martínez-Aranda et al., 2024), athletic performance (França et al., 2023; Martínez-Aranda et al., 2024), and recovery (Alonso-Calvete et al., 2022; Hendricks et al., 2020; Skinner et al., 2020); however, regarding SMR application method, most focus on application duration (Campos de Almeida et al., 2021; Phillips et al., 2021; Schroeder et al., 2021), with few examining different FR textures (Adamczyk et al., 2020; Lee et al., 2018; Michalak et al., 2024; Monteiro et al., 2019). However, two studies examining the effect of FRs in different textures have examined the effect of these tools on recovery (Adamczyk et al., 2020; Michalak et al., 2024), one comparing the effects of vibration FR and non-vibration FR (Lee et al., 2018) and the other comparing the effects of FR and stick roller (Monteiro et al., 2019). Despite its popularity, the physiological effects of SMR have not yet been fully elucidated in the scientific literature, and no consensus exists regarding the ideal program for enhancing athletic performance (França et al., 2023) or specifically for strength improvement (Duarte França et al., 2024; Hendricks et al., 2020). A recent systematic review reported that most studies found no change in performance tests following foam rolling, and that several studies did not support foam rolling intervention for performance enhancement (Hendricks et al., 2020). In one of these studies, it was found that foam rolling did not improve performance due to a decrease in biceps femoris muscle activation when only the quadriceps muscle was rolled, and the findings suggest that foam rolling has an antagonistic effect (Cavanaugh et al., 2017). Furthermore, despite the increasing use of rollers of varying densities in SMR, many authors note that there is still a lack of robust scientific evidence documenting their effects on fascia in the literature (Debski et al., 2019).

Given these uncertainties, it is thought that different foam roller textures may influence pressure distribution and tissue deformation during SMR, which could in turn lead to distinct neuromuscular responses. When SMR is used as part of a warm-up routine to maximize the athletic performance measures, the effect of FR textures on muscle strength is not well studied. As SMR has become a frequently preferred intervention by athletes in recent years, understanding the effects of FRs with different textures and densities on muscle strength in SMR applications is highly important. The outcomes of this study will enhance our understanding of how SMR, which is preferred by practitioners in the field as a warm-up routine, affects muscle strength when applied with different FR textures in the same protocol, and will provide practical recommendations to athletic performance coaches, athletes, and health professionals. Therefore, this current study aimed to investigate the acute effect of SMR with different texture FRs on knee isokinetic strength in female basketball players. We hypothesized that SMR intervention with different textures of FRs would significantly affect isokinetic strength and that muscle strength responses would differ.

Methods

Participants

Fourteen female basketball players voluntarily participated in this study (Table 1). Participants were informed about the benefits and potential risks of the study, and informed consents were obtained prior to the study. The study was conducted in accordance with the latest version of the Declaration of Helsinki and was also approved by the Ethics Committee of Gazi University (Research code: 2023–1236). The inclusion criteria for the study were: (a) active participation in basketball training (at least 5 times per week), (b) active participation in competitions as a licensed athlete in the basketball discipline, (c) having at least 4 years of basketball experience, and (d) having prior experience with quadriceps and hamstring SMR using a FR before training or competitions. The exclusion criteria of the study were: (a) participants who had any physical injury or had undergone surgery within the last six months, (b) participating in another sport discipline in addition to basketball, (c) having any existing myofascial restriction, movement limitation, or muscle pain, and (d) reporting the use of any ergogenic supplements such as creatine, amino acids, or protein powder.

Table 1
Characteristics of participants (n=14).

	Mean±*SD*	Min	Max	95% CI
Age (year)	20.5±1.7	19	25	19.2-21.1
AoE (year)	10.9±3.1	6	17	9.1-12.7
Body height (cm)	175.1±8.7	160	188	170.1-180.1
Body mass (kg)	66.0±7.3	55	80	61.8-70.2

AoE: Age of experience; SD: Standard deviation; min: minimum; max: maximum, CI: Confidence interval.

Study Design

To determine the acute effects of SMR with different texture FRs on knee isokinetic strength in female basketball players, a randomized, crossover, within-subject design was used in this present study. The experimental procedures of this study were completed in three sessions, each separated by 72 h, for a total of 7 days, at the same time of day for each participant. The study was conducted at the Sports Biomechanics Laboratory of Gazi University, where environmental conditions were maintained within standard laboratory ranges (approximately 19–25°C and 45–52% humidity). Participants were instructed to refrain from performing strenuous lower extremity exercises within 48 h prior to testing and from consuming any stimulants (such as caffeine) within 12 h before the measurement session. On the first day, the characteristics of the participants were determined prior to measurement. In three separate sessions, the knee isokinetic strength of basketball players was measured following the baseline, SMR using superficial foam rolling with grid surface FR (GRID-SMR), and SMR using deep tissue foam rolling with high-profile bumps (DTR-SMR) protocols in accordance with a randomized crossover design (Figure 1).

Procedure

In the first session, after recording the participants' characteristics, their dominant leg was determined. Gonzalo-Skok et al. (2023), the dominant leg was defined as the leg used during the first step in a lay-up, whereas that used during the second step was the non-dominant leg. Subsequently, all athletes performed a standardized warm-up protocol. The warm-up consisted of 5 min of cycling on an ergometer at 60 rpm, followed by 3 min of dynamic warm-up (90-90 hip rotation, lying single leg knee to chest dynamic stretch, lying hamstring full extension stretch, active straight leg raise, lunge and thoracic rotation, mini skipping, high knees, single leg high knees (right/left), dynamic straight leg, glute kicks, walking toe touches- each for 15 s), and 2 min of static stretching (standing quadriceps stretch, seated hamstring stretch, calf stretch, deep glute stretch, achilles stretch, inner hamstring stretch, IT band stretch, butterfly stretch, hip flexor stretch- each for 12 s) (total warm-up duration: 10 min). This structure was developed based on previously reported dynamic warm-up models with similar exercise durations and movement patterns (Frikha et al., 2016; Samson et al., 2012; Wong et al., 2011), and slightly modified to align with the specific aims of the present study. The same warm-up protocol was performed in each session. A 2 min rest period was given after the warm-up. Participants were randomized in a crossover design to 3 separate sessions with a 72 h interval and were subjected to the same time of day (Kurt et al., 2023). Previous studies have suggested that during foam rolling, SMR is completed through the isometric contraction of postural muscles and that SMR procedures create a warming effect on the myofascia, which may influence athletic performance (Beardsley & Škarabot, 2015; Healey et al., 2014). Therefore, to replicate the conditions of the SMR intervention, athletes remained for a total of 3 min in the same seated and prone positions used during the SMR protocols, following the warm-up in the baseline protocol (Phillips et al., 2021). In all protocols, measurements began with the dominant leg hamstrings, immediately followed by the dominant leg quadriceps. Although the effects of the exercises performed during the warm-up are known to last at least 10 min, it has been reported that changes in muscle stiffness were observed only 5 min after the exercises (Konrad et al., 2019; Schroeder et al., 2021). Therefore, after the 3 min dominant leg SMR intervention (90 s hamstrings+90 s quadriceps=3 min), a 5 min rest interval was given, and subsequently the isokinetic strength measurement of the dominant side was performed. After a 2 min rest following the isokinetic strength test, the non-dominant leg SMR was applied, first to the hamstrings and then immediately to the quadriceps (90 s hamstrings+90 s quadriceps=3 min). After SMR, a 5 min rest interval was given, followed by the isokinetic strength measurement of the non-dominant side.

SMR Protocols

To determine the acute effects of SMR with FRs of different textures on isokinetic strength, a 30 × 15 cm grid-surface foam roller (GRID) — medium density (Adamczyk et al., 2020; Monteiro & Neto, 2016) and a 55 × 14 cm deep tissue foam roller (DTR) with “high-profile bumps” — hard density (The Rumble Roller; STI, Baton Rouge, LA, USA) (Behara & Jacobson, 2017; Michalak et al., 2024) were used. In SMR, the rolling speed was set at 60 bpm and maintained using a cell phone metronome application. Foam rolling was applied to the hamstrings and quadriceps muscle groups of the lower extremity. For hamstrings SMR (Figure 2a-b), athletes were instructed to roll the FR up-and-down between the ischial tuberosity and the popliteal fossa in a seated position (Madoni et al., 2018). For quadriceps SMR, in a prone position (Figure 2c-d), the application leg was extended in contact with the FR, while the other leg was flexed and positioned laterally in a relaxed manner.

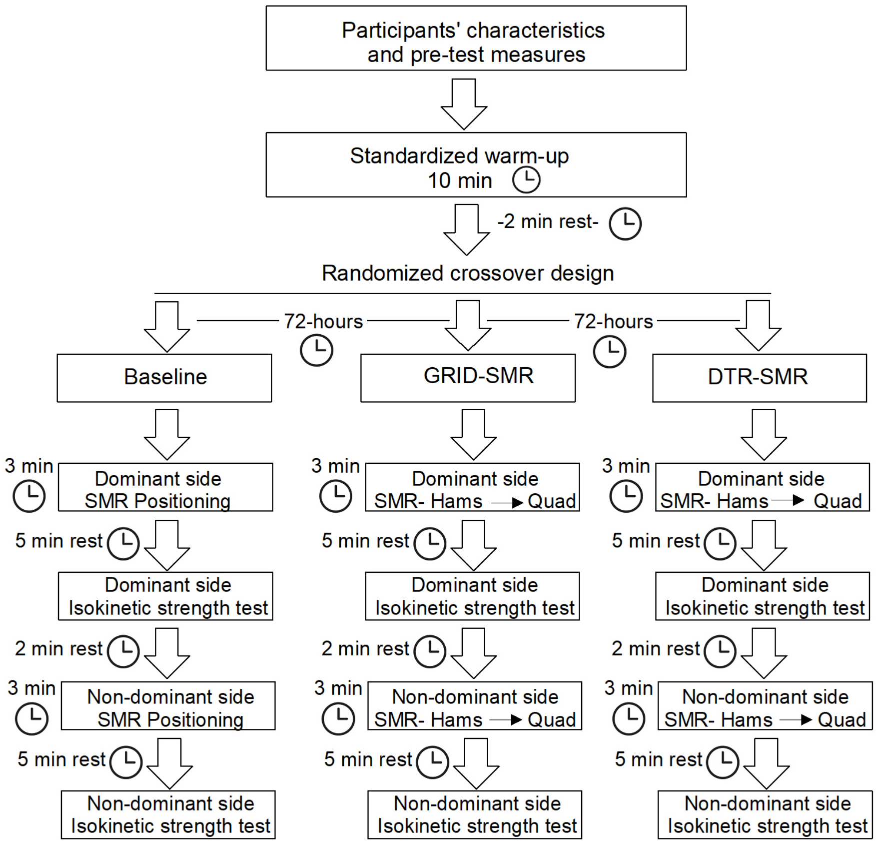

Figure 1. Study design of the experimental protocol. GRID-SMR: Self-myofascial release intervention using grid surface foam roller, DTR-SMR: Self-myofascial release intervention using deep tissue foam roller.

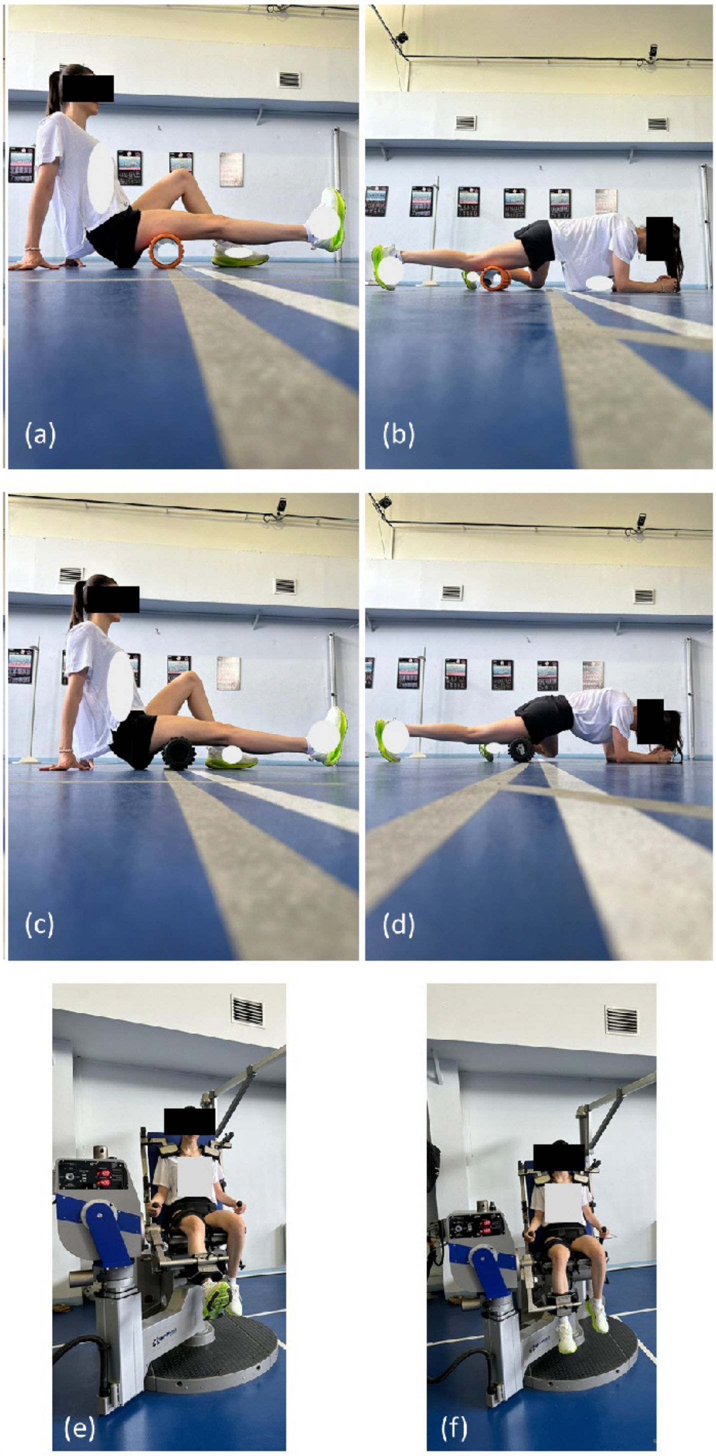

Figure 2. Experimental procedures for GRID-SMR (a, b), and DTR-SMR (c, d) interventions applied to hamstrings and quadriceps and isokinetic strength testing (e, f).

Athletes were instructed to roll up-and-down on the anterior thigh between the acetabulum and the patellar tendon (Monteiro & Neto, 2016). When performing foam rolling, the pressure force was determined by the participants, ensuring that the applied force did not cause pain but was sufficient to produce only a sense of discomfort (Michalak et al., 2024; Monteiro et al., 2018; Peacock et al., 2015; Phillips et al., 2021). To see the optimal effect of SMR, it is recommended to perform the foam rolling for 90-120 s (Hendricks et al., 2020; Skinner et al., 2020). Therefore, the SMR duration was 90 s for each muscle group in a single set. Hamstrings SMR was immediately followed by quadriceps SMR was performed without any rest interval. Familiarization was not applied because all participants used SMR interventions in their daily training routines. Although all participants reported prior foam rolling experience, proper foam rolling technique was monitored by the researchers during both testing sessions (Cornell & Ebersole, 2020).

Knee Isokinetic Strength Test

To determine knee isokinetic strength, the ISOMED 2000 isokinetic dynamometer (D&R Ferstl GmbH, Hemau, Germany) was used to perform the knee flexion and extension isokinetic strength test at $60°·s^{-1}$ in concentric/concentric mode. The test was applied separately to the dominant and non-dominant leg, consisting of 2 familiarization trials and 5 test repetitions (Figure 2e-f). Verbal encouragement was provided during the test repetitions. While seated on the dynamometer, the athletes were stabilized at the shoulders, hips, and legs (Campos de Almeida et al., 2021). In the evaluation of knee isokinetic strength, peak torque (PT) (Nm), relative torque (PT/W) ($Nm·kg^{-1}$), degree at peak torque (DPT) (°), work (joule), relative work ($joule·kg^{-1}$), total work (joule), and power (watt) data were recorded separately for flexion and extension. The flexion values represent the hamstrings muscle group (H), while the extension values represent the quadriceps muscle group (Q).

Data Analyses

The data are presented as mean±SD, 95% confidence interval (CI), and significance level (p). Data normality was tested using a Shapiro-Wilks test. Repeated measures analyses of variance (RM ANOVAs) were used to compare knee isokinetic strength responses after SMR with FRs of different textures. In these analyses, the assumption of sphericity was verified using Mauchly's test, and when violated, the Greenhouse–Geisser correction was applied. Since some variables did not meet the assumption of normal distribution ($p<.05$), a non-parametric Friedman repeated-measures ANOVA on ranks was conducted instead of the parametric RM-ANOVA. Therefore, sphericity assumption checks (e.g., Mauchly's test) were not applicable. If a significant effect was found, all pairwise multiple comparison procedures (Holm-Sidak method) were used to identify significant differences between the protocols. Partial eta squared (η^2_p) were classified as follows: small (.01), moderate (.06), and large (.14) (Cohen, 1988). Statistical analysis was performed using SigmaPlot 11.0 (from Systat Software, Inc., San Jose, California, USA). The level of significance was set at $p<.05$.

Results

Knee flexion PT showed no significant differences between the baseline protocol, GRID-SMR, and DTR-SMR protocols in either leg (dominant: $p=.968$, non-dominant: $p=.298$) (Table 2). However, knee extension PT significantly decreased in the dominant side after GRID-SMR compared to the baseline protocol (baseline vs. GRID-SMR: $F=13.43$, $p=.014$, "large" $\eta^2_p=.311$). Knee extension PT in the non-dominant leg was not significantly different between the protocols ($p=.534$). In addition, knee extension and flexion PT/W and DPT were not significantly different between the protocols in either leg ($p>.05$).

Table 2
Knee isokinetic strength flexion (H) and extension (Q) PT, PT/W, and DPT in female basketball players following SMR with different textures of FRs (n=14).

		Baseline[a]		GRID-SMR[b]		DTR-SMR[c]		*p*
		Mean±*SD*	95% CI	Mean±*SD*	95% CI	Mean±*SD*	95% CI	
$PT_{Flex(H)}$ (Nm)	D	90.1±16.0	80.9-99.3	90.4±12.0	83.5-97.3	89.8±13.9	81.8-97.8	.968
	ND	92.8±18.4	82.2-103.4	90.7±12.6	83.4-97.9	87.8±17.1	77.9-97.7	.298
$PT_{Ex(Q)}$ (Nm)	D	164.2±28.5	141.9-186.4	149.3±23.1	135.9-162.6	153.0±19.8	141.6-164.4	a-b, .014
	ND	159.2±24.0	145.3-173.1	155.2±19.4	143.9-166.4	153.3±18.9	142.4-164.2	.534
$PT/W_{Flex(H)}$ ($Nm.kg^{-1}$)	D	1.23±.19	1.12-1.33	1.31±.18	1.21-1.41	1.26±.17	1.16-1.36	.089
	ND	1.23±.22	1.10-1.36	1.31±.17	1.21-1.41	1.26±.19	1.15-1.37	.151
$PT/W_{Ex(Q)}$ ($Nm.kg^{-1}$)	D	2.19±.24	2.05-2.32	2.19±.23	2.06-2.32	2.15±.27	1.99-2.31	.838
	ND	2.18±.27	2.02-2.34	2.23±.21	2.11-2.35	2.15±.25	2.01-2.29	.536
$DPT_{Flex(H)}$ (°)	D	45.8±8.3	41.0-50.6	44.8±9.9	39.1-50.5	42.4±11.5	35.8-49.0	.253
	ND	44.1±10.4	38.1-50.1	42.4±10.9	36.1-48.7	40.4±6.9	36.4-44.4	.250
$DPT_{Ex(Q)}$ (°)	D	60.8±4.2	58.4-63.2	62.9±5.1	59.9-65.8	60.6±4.2	58.2-63.0	.125
	ND	69.4±5.4	66.3-72.5	61.5±5.1	58.6-64.4	61.8±4.8	59.0-64.6	.189

PT: Peak torque; Flex: flexion; Ex: Extension; H: Hamstrings; Q: Quadriceps; W: Weight; DPT: Degree at peak torque; D: Dominant; ND: Non-dominant; [a]: Baseline; [b]: GRID-SMR; [c]: DTR-SMR; SD: Standard deviation; CI: Confidence interval; p<.05.

Table 3
Knee isokinetic strength flexion (H) and extension (Q) work, relative work, total work and power in female basketball players following SMR with different textures of FRs (n=14).

		Baseline[a]		GRID-SMR[b]		DTR-SMR[c]		*p*
		Mean±*SD*	95% CI	Mean±*SD*	95% CI	Mean±*SD*	95% CI	
$Work_{Flex(H)}$ (Joule)	D	82.7±10.3	76.8-88.6	84.3±11.3	77.8-90.8	87.7±13.6	79.8-95.6	.801
	ND	82.1±13.1	74.5-89.7	87.6±13.4	79.9-95.3	85.7±17.4	75.7-95.7	.945
$Work_{Ex(Q)}$ (Joule)	D	125.6±16.3	116.2-135.0	127.9±20.9	115.8-139.9	127.9±19.2	116.8-138.9	.849
	ND	125.8±11.0	119.4-132.2	130.8±17.6	120.6-140.9	128.4±17.3	118.4-138.4	.232
$Work/W_{Flex(H)}$ (Joule. kg^{-1})	D	1.09±.34	.89-1.29	1.14±.37	.93-1.35	1.04±.40	.81-1.27	.223
	ND	1.01±.37	.79-1.22	.99±.46	.72-1.26	.96±.36	.75-1.17	.810
$Work/W_{Ex(Q)}$ (Joule. kg^{-1})	D	.60±.36	.39-.81	.60±.50	.31-.89	.51±.22	.38-.64	.567
	ND	.42±.15	.33-.51	.51±.24	.37-.65	.43±.22	.30-.56	.104
Total $Work_{Flex(H)}$ (Joule)	D	412.2±52.4	381.9-442.5	426.1±65.0	388.6-463.6	424.4±71.2	383.3-465.5	.510
	ND	409.9±66.2	371.7-448.1	436.8±67.5	397.8-475.8	428.1±85.1	378.9-477.2	.880
Total $Work_{Ex(Q)}$ (Joule)	D	627.7±81.6	580.6-674.8	641.2±105.2	580.5-701.9	639.4±95.6	584.2-694.6	.982
	ND	628.4±55.7	596.2-660.6	654.9±88.8	603.6-706.2	639.4±86.3	589.6-689.2	.245
$Power_{Flex(H)}$ (Watt)	D	58.1±9.3	52.8-63.7	62.9±9.7	57.3-68.5	61.8±10.9	55.5-68.1	.078
	ND	56.7±9.5	51.2-62.2	63.0±9.4	57.6-68.4	63.1±12.5	55.9-70.3	a-b, .011 a-c, .021
$Power_{Ex(Q)}$ (Watt)	D	92.1±13.1	84.5-99.7	98.6±18.8	87.7-109.5	95.5±14.5	87.1-103.9	.161
	ND	91.4±11.9	84.5-98.3	95.5±12.4	88.3-102.7	94.9±12.8	87.5-102.3	.443

Flex: flexion; Ex: Extension; H: Hamstrings; Q: Quadriceps; W: Weight; D: Dominant; ND: Non-dominant; [a]: Baseline; [b]: GRID-SMR; [c]: DTR-SMR; SD: Standard deviation; CI: Confidence interval; p<.05.

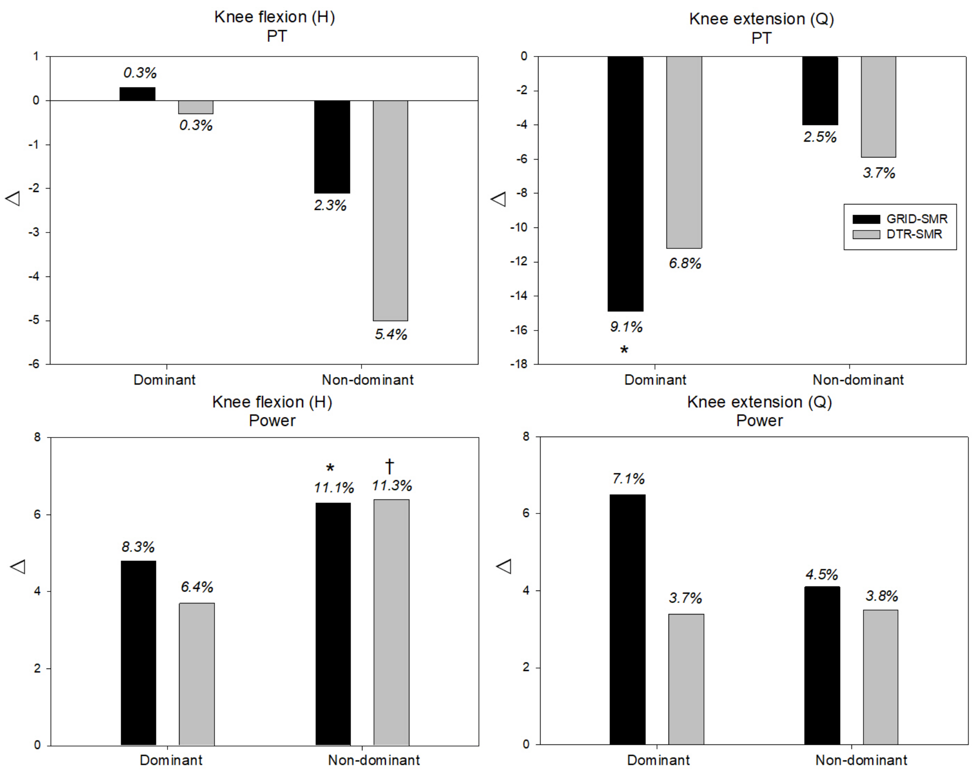

Figure 3. Changes in isokinetic PT and power after GRID-SMR and DTR-SMR. Δ represents absolute differences compared to the baseline protocol, while quantitative data in each column represents percentage change. *Statistically significant difference between baseline and GRID-SMR, †Statistically significant difference between baseline and DTR-SMR.

In the knee flexion and extension isokinetic strength test, work, relative work, and total work showed no significant differences between the protocols on either the dominant or non-dominant side (p>.05, Table 3). In addition, knee extension power in either leg (dominant: p=.161, non-dominant: p=.443) and knee flexion power in the dominant leg (p=.078) were not different between the protocols. But, knee flexion power of the non-dominant side significantly increased after GRID-SMR (baseline vs. GRID-SMR: F=11.33, p=.011, "large" η^2_p=.308) and after DTR-SMR (baseline vs. DTR-SMR: F=11.45, p=.021, "large" η^2_p=.306).

Discussion

This study examined the acute effects of SMR using FRs of different types on isokinetic knee strength in female basketball players. The first main finding was that quadriceps PT significantly decreased only in the dominant leg after GRID-SMR compared to the baseline protocol (p=.014, η^2_p=.311, Δ=-14.9). However, quadriceps power outputs were not found to be significantly different between the protocols in either leg. The second main finding was that hamstring PT was not significantly different between the protocols in either leg. However, non-dominant leg power increased significantly following SMR protocols (post-GRID-SMR: p=.011, η^2_p=.308, Δ=6.3, post-DTR-SMR: p=.021, η^2_p=.306, Δ=6.4) (Figure 3). The findings confirmed the hypothesis that SMR intervention with FRs of different textures would significantly affect isokinetic strength and that muscle strength responses would differ.

No significant changes were observed in hamstrings PT of either the dominant or non-dominant leg following both GRID-SMR and DTR-SMR. This suggests that the maximal force-generating capacity of the hamstrings may not be substantially influenced by short-term release interventions by different textures of FR. However, the significant increase in hamstrings power of the non-dominant leg implies that SMR might enhance the efficiency of force production when combined with velocity in less-trained or less-utilized limbs. This improvement may reflect the greater adaptability of the non-dominant limb, whereas the dominant side, already exposed to higher neuromuscular demand in sport-specific actions, may display greater resistance to acute intervention-induced changes. To the authors' knowledge, the absence of previous studies investigating isokinetic strength responses to pre-exercise applications of GRID-SMR and DTR-SMR constitutes a limitation for discussing the results. Nevertheless, from a recent perspective, a systematic review emphasized that SMR has acute positive effects on flexibility and RoM without affecting muscle performance during maximal strength and power actions (Martínez-Aranda et al., 2024), whereas a meta-analysis reported that the effects of FR used during warm-up on strength performance were negligible (+1.8%, g=0.12), and FRs tended to provide greater effects on the recovery of strength performance compared to roller massagers (Wiewelhove et al., 2019). On the other hand, a systematic review clearly stated that foam rolling does not enhance performance when used during warm-up (Hendricks et al., 2020). Previous studies have reported a significant decrease in strength and/or power after SMR (Arroyo-Morales et al., 2011; Cavanaugh et al., 2017; Janot et al., 2013; Madoni et al., 2018; Sagiroglu et al., 2017), a significant increase (Kurt et al., 2023; Lee et al., 2018; Richman et al., 2019; Stroiney et al., 2020) or no significant difference (Behara & Jacobson, 2017; Campos de Almeida et al., 2021; Cornell & Ebersole, 2020). In healthy adult males, it was concluded that 3- and 5 min SMR did not produce significant differences in quadriceps isokinetic PT, total work, and power compared to the placebo group (Campos de Almeida et al., 2021). Similar to this study, which examined the acute effect of myofascial release intervention duration on isokinetic strength, our findings also showed comparable results — except for non-dominant leg hamstring power and dominant leg quadriceps PT. However, due to certain methodological differences—such as the intervention not being SMR, the participants not being athletes or female, the application duration being much longer compared to our study, and the absence of repeated measurements in the same individuals—the similarity of the findings should be interpreted with caution. In contrast, after FR-based SMR intervention of the entire lower extremity, female participants showed significantly lower peak power output and power drop compared to the control condition (p<.05) (Janot et al., 2013). The researchers reported that SMR caused a decrease in muscle strength by inducing changes in the length–tension relationship. In jump capacity, which is one of the key indicators reflecting muscle strength and power, the findings are noteworthy in terms of inconsistency, with some studies reporting a significant decrease after SMR (Sagiroglu et al., 2017), while others show a significant increase (Richman et al., 2019; Stroiney et al., 2020). Unfortunately, differences in application durations, participant groups, and types of SMR tools are likely to have influenced the results. However, the findings of our study demonstrate that both types of SMR interventions increase non-dominant leg power, which may bring unilateral SMR application into consideration for athletes experiencing asymmetry scenarios.

Regarding the quadriceps, a significant decrease in PT of the dominant leg was observed after GRID-SMR compared with the baseline protocol. This reduction may indicate a temporary inhibition of quadriceps activation or a reduction in muscle tone, suggesting that GRID-SMR might acutely attenuate maximal strength capacity in highly utilized muscles. Nevertheless, quadriceps power values remained unaffected across all protocols, highlighting that explosive performance outcomes, which rely heavily on contraction velocity as well as force, were not compromised despite reductions in PT. It has been reported that SMR intervention with 3 sets of 60 s of foam rolling on the vastus lateralis did not affect the electro-mechanical aspects of muscle activation during maximal voluntary isometric contractions in recreationally active participants, and that the findings supported no decrease in strength output following SMR (Cornell & Ebersole, 2020). Similarly, in another study, quadriceps PT (p=.63) and mean torque (p=.11), as well as hamstrings PT (p=.63) and mean torque (p=.22), did not significantly change after DTR-SMR compared to the baseline protocol (Behara & Jacobson, 2017). In another study, biceps femoris activation significantly decreased (p=.015, 28.9%) after quadriceps foam rolling; however, no significant decrease in quadriceps activation was observed following hamstrings foam rolling (Cavanaugh et al., 2017). The authors emphasized that this result might be related to the finding that quadriceps FR application produced significantly greater levels of perceived pain (p<.001). In contrast, in twenty-three healthy female athletes, knee extension and flexion isokinetic strength at an angular velocity of $60°.s^{-1}$ was found to significantly increase following dynamic stretching and SMR interventions compared to static stretching (Kurt et al., 2023). Contrary to the above studies, there are also studies that support the findings of our research and show a decrease in muscle strength after SMR. In one of these, after hamstrings SMR intervention with 30 s x 3 sets of 10 s rest interval, although RoM increased in recreationally active women, significant decreases were observed in hamstrings PT (pre vs. post: 70.8±3.9 - 66.4-4.1 Nm, percent change: -6.17, p<.05) and H:Q ratio (pre vs. post: 0.63±0.03 – 0.60±0.03, percent change: -6.14 p<.05) at $60°.sec^{-1}$ angular velocity (Madoni et al., 2018). Another study showed that pre-activity massage negatively impacted subsequent muscle performance by reducing knee flexion and knee extension isokinetic PT at higher speeds (p<0.05) (Arroyo-Morales et al., 2011). Authors of this study have noted that pre-event massage negatively impacts muscle performance, likely due to increased parasympathetic nervous system activity, resulting in decreased afferent input and decreased motor unit activation. However, in this study, SMR was applied not only to the quadriceps and hamstrings but also to the hips, and the application time was 30 s x 3 sets. Therefore, these results, which differ from the findings in our study, may have been influenced by the application duration and the regions targeted. Our study clearly demonstrates that while there was no significant change in hamstrings PT following the 90 s × 1 set SMR protocols, there was a significant decrease in dominant leg quadriceps PT only after GRID-SMR. As Cavanaugh et al. (2017) mentioned, our results may also have been influenced by the difficulty of applying quadriceps SMR. In addition, the application duration for the dominant leg may have altered maximal strength capacity by reducing muscle tone. However, the absence of the same effect after DTR-SMR is an important finding for athletes and coaches, indicating that compared to GRID-SMR, DTR-SMR may be a more preferable protocol for maximum muscle strength.

Several limitations of the current study should be acknowledged. The first is that, although there are a few studies on the acute effect of SMR on isokinetic strength, there is a lack of previous studies in the literature that can be compared with our results. The second is that the amount of pressure applied by participants using their own body weight during foam rolling in SMR protocols could not be controlled beyond the researchers ensuring the appropriate FR form. A slight change in pressure among participants may have led to different amounts of relative force being applied to the FR, which could theoretically affect SMR mechanisms. Furthermore, although participants were instructed not to engage in physical activity involving weight-bearing on the lower extremities for 48 h prior to the tests, the only way to control for this variable was to ask volunteers before the tests whether they had followed the previous recommendations. Finally, the limited sample size and the participation of only adult female basketball players necessitate confirmation in future studies regarding the generalizability of the results.

Conclusion

The findings of this study demonstrate that the acute effects of SMR interventions with FRs of different textures on isokinetic strength and power parameters vary depending on the muscle group, leg dominance, and type of intervention. Taken together, the findings of this study suggest that SMR with FRs of different textures may exert selective and task-specific effects on knee isokinetic strength. Although neither intervention altered hamstring PT and quadriceps power, GRID-SMR was found to increase power in the non-dominant hamstrings and decrease PT in the dominant quadriceps following application, while DTR-SMR only increased non-dominant hamstrings power. Therefore, it is recommended that DTR-SMR can be safely incorporated into warm-up routines prior to sport-specific activities, whereas GRID-SMR should be applied with caution before tasks requiring maximal strength output. These practical insights provide valuable guidance for coaches and practitioners in designing effective and safe warm-up strategies. In addition, the observed improvements in non-dominant hamstring power following both SMR interventions indicate that foam rolling may help reduce inter-limb asymmetries in power output. This suggests that targeted SMR applications could serve as a useful strategy for managing limb asymmetries and maintaining balanced muscle performance, particularly in sports requiring symmetrical lower-limb function. The findings of this study provide important insights for strength and conditioning coaches, players, practitioners, and health professionals, offering practical recommendations for performance enhancement in warm-up strategies.

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Authors' Contribution

Study Design: PEC, ÇÖC, SS and EC; Data Collection: PEC, ÇÖC; Statistical Analysis: SS, EC; Manuscript Preparation: PEC, ÇÖC, SS and EC; Funds Collection: PEC, ÇÖC, SS and EC.

Ethical Approval

The study was approved by the Ethics Committee of Gazi University (Research code: 2023–1236) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a Declaration of Helsinki.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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