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Research Article

Acute Effects of Dynamic Stretching and Foam Rolling Warm-Up Protocols on Certain Performance Parameters in Canoeists

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Abstract: This study aimed to investigate the acute effects of warm-up protocols involving dynamic stretching (DS) and foam rolling (FR) on specific performance parameters in canoe athletes. By examining the individual and combined effects of these two warm-up methods on performance, the study sought to provide a scientific basis for identifying the most effective warm-up strategy. A total of 13 volunteer flatwater canoe athletes (age: 13.07±1.32 years; training age: 3.07±1.32 years; height: 1.60±0.11 cm; body weight: 51.07±11.96 kg; body mass index: 19.61±2.79 kg/m²) participated in the study. The research employed a randomized, crossover, counterbalanced experimental design and was conducted over three test days with 48-hour intervals. On each test day, participants were randomly assigned to one of three warm-up protocols: FR only, DS only, or a combination of FR+DS. Following each warm-up protocol, performance tests including vertical jump, visual re-action time, flexibility, back and leg strength, and balance were conducted. Additionally, the Borg Scale (RPE) was used to assess perceived exertion, and the Visual Analog Scale (VAS) was administered to rate delayed onset muscle soreness (DOMS). Differences between variables were analyzed using repeated-measures ANOVA. The results revealed no statistically significant differences among the groups in terms of vertical jump, anaerobic power, back and leg strength, balance, RPE, VAS, or visual reaction time values ($p>0.05$). However, a statistically significant difference was observed in flexibility values between the FR and FR+DS groups ($p<0.05$). In conclusion, the FR+DS warm-up protocol led to a significant improvement in flexibility. For other performance parameters, the different warm-up protocols produced similar effects. The findings suggest that, in selecting warm-up protocols for canoe athletes, the choice of strategy should be guided by the targeted performance parameter, and that combining methods may be beneficial depending on specific performance goals.

Keywords: Canoe, warm- up, foam rolling, dynamic stretching, performance.

1. Introduction

Canoeing is a water sport performed individually or in teams, either on flatwater or whitewater courses, aiming to complete a linear route in the shortest possible time (Kocahan et al., 2020). Canoeing is divided into two Olympic disciplines: flatwater and slalom (whitewater). These disciplines differ in terms of boat structure, paddling techniques, seating positions, and race formats (Akça & Müniroğlu, 2006). In this sport, athletes perform movements that require a high level of physical capacity, balance, flexibility, and coordination. Canoeing creates intense physiological demands on upper extremity and trunk muscle groups (Tesch, 1983). Studies in the literature report that athletes in this branch have high maximum aerobic and anaerobic capacities as well as upper body muscle strength (Bishop, 2000; Fry and Morton, 1991; Gray et al., 1995). However, it has led to a noticeable gap in research, particularly regarding warm-up protocols that influence performance parameters.

Dynamic stretching is a stretching technique characterized by controlled movements that extend muscles to the limits of their range of motion through sequential and rhythmic contraction-relaxation cycles. This method is applied based on the resistance created throughout the joint's range of motion and is frequently utilized both during warm-up routines and for enhancing performance (Zorba & Saygın, 2007; Şener et al., 2025). In recent years, research into the physiological effects of myofascial release techniques has demonstrated their effectiveness in both pain reduction and tissue recovery support (Arroyo-Morales et al., 2008; Fryer et al., 2009; Kraemer et al., 2010; Anderson et al., 2011). The most common physiological response is vasodilation, or the widening of the arterial system, which leads to increased blood flow to the targeted area. As a result, positive changes such as improved soft tissue repair, elevated nitric oxide (NO_2) levels, and enhanced vascular plasticity have been observed (Okamoto et al., 2014). These physiological reactions contribute to therapeutic effects on pain control and recovery processes. Self-administered myofascial release involves applying pressure to soft tissue using body weight and a foam rolling (Ateş & Yitik, 2018). FR, a form of self-myofascial release, offers several physiological benefits including increased arterial dilation, reduced fascial restrictions, improved muscle elasticity, and enhanced neurological feedback (Peacock et al., 2014; Healey et al., 2014; Freiwald et al., 2016; Behara & Jacobson, 2017; Smith et al., 2018; Richman et al., 2019).

Today, FR techniques are increasingly being used not only for recovery but also as a pre-performance warm-up method. It has been suggested that FR, similar to static and dynamic stretching, improves joint range of motion and may serve as an alternative warm-up strategy (Konrad et al., 2022; Wilke et al., 2020). The application of FR and DS protocols, either separately or in combination, prior to training or competition, constitutes an important area of research in terms of their effects on athletic performance. Although various warm-up protocols have been investigated in the literature for their acute effects on different performance parameters, no study has been found that directly compares the effects of these protocols on multiple performance variables—such as flexibility, vertical jump, anaerobic power, muscle strength, balance, and visual reaction time—specifically within the context of canoeing. In this regard, the present study aims to provide discipline-specific findings by evaluating these parameters from a holistic perspective. Furthermore, the acute effects of pre-performance FR warm-up protocols remain inconclusive, underscoring the necessity of further investigation. Accordingly, the aim of this study is to examine the acute effects of warm-up protocols involving FR and DS on selected performance parameters in canoe athletes. The hypothesis of the study is that FR and DS protocols will produce varying levels of acute effects on performance parameters.

2. Materials and Methods

2.1. Research Design

A quantitative research model was employed in this study. A randomized, crossover, and counterbalanced experimental design was used to examine the acute effects of the warm-up protocols.

2.2. Research Group

The study involved 13 trained male canoe athletes aged between 11 and 15 years A priori power analysis determined that a sample size of 12 participants was sufficient (Effect size: 0.50, Confidence interval: 1-β = 0.95, Significance level: α = 0.05, Actual power: 0.95). The participants were selected from canoe athletes affiliated with the Sinop Provincial Directorate of Youth and Sports. Inclusion criteria required participants to be healthy, without any chronic or acute illnesses, and to have no movement restrictions due to injury. To ensure the reliability of the study and minimize the effects of differing training regimens, all participants were recruited from athletes following the same training program.

2.3. Data Collection Tools

2.3.1. Anthropometric Measurements

Athletes' height was measured in centimeters using a portable stadiometer (Seca 213), and body weight was assessed in kilograms using a bioelectrical impedance body composition analyzer (Inbody 120). Body mass index (BMI) was calculated by dividing body weight (kg) by the square of height in meters (kg/m2) (Mor et al., 2021).

2.3.2. Reaction Time Test

In this study, the reaction time of the canoe athletes was measured using a reaction measurement device (LightTrainer Reaction Development and Exercise System, Istanbul, Türkiye). The device consists of six wireless modules equipped with lights and proximity sensors (capable of detecting objects within 10 cm), which transmit real-time data wirelessly via Bluetooth to a mobile application on a smartphone or tablet using proprietary software. Athletes began the reaction time test from a distance of 1 meter from the modules, following the researcher's "ready" command. The test commenced with the illumination of the first light and concluded when the athlete deactivated all 30 light signals across the modules. If a participant made contact with or damaged a module—resulting in dislocation or malfunction—the trial was considered invalid and was repeated (Mor et al., 2022).

2.3.3. Flexibility

Flexibility levels of the athletes, particularly concerning the lower extremities and lumbar extensor muscle groups, were assessed using a sit-and-reach box (S&R brand). Participants assumed a long sitting position with bare feet flat against the sit-and-reach apparatus and ankles at a 90-degree angle. They were instructed to lean forward without bending their knees and to push the measurement ruler on the box as far as possible with their hands, holding the furthest position for 2 seconds. The distance reached was recorded in centimeters as the flexibility score (Fox et al., 1989; Çolakoğlu et al., 2014).

2.3.4. Vertical Jump and Anaerobic Power Test

Vertical jump performance was assessed using a digital vertical jump device (Takei 5406 Jump-MD Vertical Jump Meter, Tokyo, Japan). The rubber vertical jump plate was first placed on a flat surface. To eliminate the possible effects of different shoe types on the results, participants were instructed to remove their shoes and stand barefoot in a "ready" position, with their feet centered on the plate about 10–20 cm apart. Once ready, the athletes quickly moved from an upright standing position to a 90° knee flexion with free arm swing and jumped for maximum height (Mor et al., 2022; Atıcı & Bayrakdar, 2025). Anaerobic power was calculated using the Lewis formula based on body weight and vertical jump height: Anaerobic Power (W) = $\sqrt{4.9} \times$ [Body Weight (kg)] $\times \sqrt{\text{Vertical Jump Height (m)}}$ (Fox et al., 1993).

2.3.5. Balance Measurement

Balance performance was measured using the Togu Challenge Disc 2.0 (Prien am Chiemsee, Rosenheim, Germany), a balance device with a platform capable of multidirectional movement, creating an unstable surface. Participants stood barefoot on the device with both feet placed on the platform. The researcher showed the application on the tablet at eye level to the athlete, and the athlete stood barefoot on the platform to eliminate the possible effects of different types of shoes on the results. The balance test required athletes to maintain focus on the darkest and innermost of a series of concentric circles displayed on the device's screen for 20 seconds. At the end of the 20-second test, the balance score was automatically recorded (Mor et al., 2022).

2.3.6. Back Strength

Back strength was measured using a back dynamometer (Takei 5402, Japan). Participants stood with slightly bent knees and legs in a neutral position, maintaining a straight back and a slightly forward-leaning torso. They were instructed to pull the dynamometer bar upward with maximal force using both hands. The device was recalibrated after each measurement. Strength values were recorded in kilograms (kg) (Kanık & Mor., 2025).

2.3.7. Leg Strength

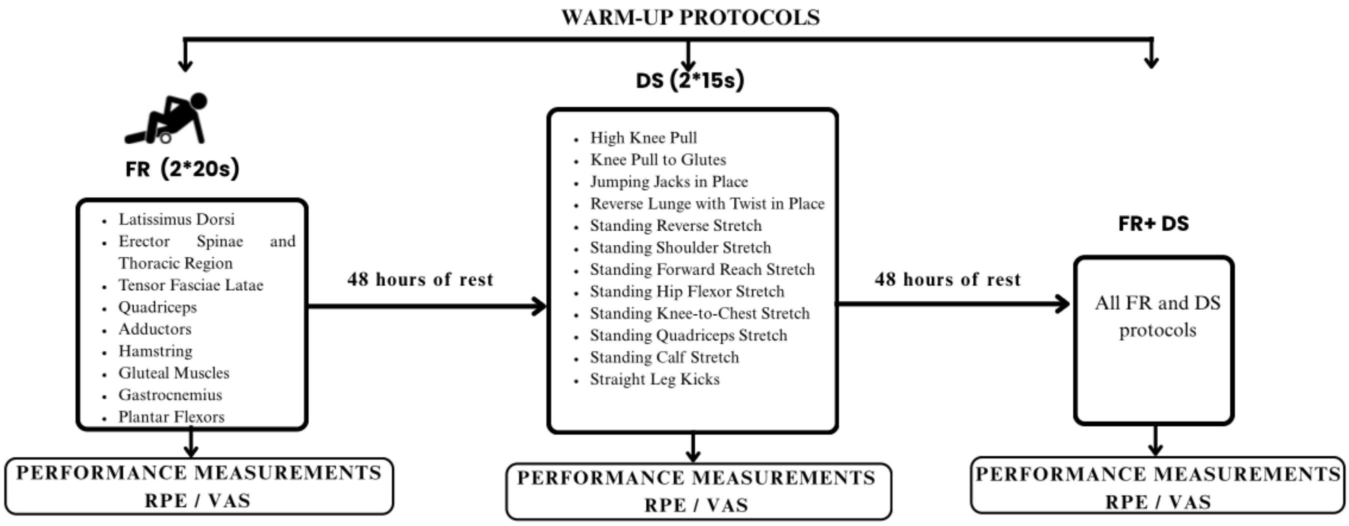
Leg strength was assessed using a leg dynamometer (Takei 5402, Japan). Participants performed a vertical pull with maximum effort by gripping the dynamometer bar while standing with bent knees, straight backs, slightly forward-leaning torsos, and extended arms (Saygın et al., 2005; Mor et al., 2021).

2.3.8. Borg Scale (Rate of Perceived Exertion – RPE)

The Rate of Perceived Exertion (RPE) is a method used to assess athletes' perceived effort during physical activity. The scale, originally developed by Borg (1998), ranges from 0 (rest) to 10 (maximum effort), with higher values indicating greater perceived exertion. Immediately after each test, participants were asked to rate the perceived difficulty they experienced in their bodies, and their responses were recorded.

2.3.9. Visual Analog Scale (VAS)

One of the tools frequently used to subjectively evaluate athletes' physical and psychological states is the Visual Analog Scale (VAS). Developed by Albersnagel (1988), this scale is designed to assess individuals' momentary emotional states and measures four primary dimensions: dysphoria, hostility, anxiety, and positive affect. Participants indicate their current psychological state by marking a point on a line graded either from 0 to 10 or from 0 to 100. Higher scores on the scale reflect greater intensity of the respective emotional dimension.



FR= Foam Rolling; DS= Dynamic Stretching; RPE=Perceived Difficulty Level; VAS=Visual Analog Scale

Figure 1. Schematic diagram of the study

2.4. Data Collection

All participating athletes were introduced to the study protocol prior to the study. Additionally, two days before the actual testing, a familiarization session was conducted during which participants were asked to practice the test protocols at a low intensity, without exerting themselves. The study was carried out using a randomized, crossover, and counterbalanced experimental design. Initially, participants' height and body weight were measured, and their body mass index (BMI) was calculated. Each athlete participated in a total of three separate test days. On each test day, participants were randomly assigned to one of the three warm-up protocols: FR, DS, or combination of FR+DS. The study design ensured that every participant experienced all three warm-up protocols. A 48-hour rest period was provided between each test session to ensure adequate recovery. Following the warm-up protocol on each test day, participants underwent a series of performance assessments, including vertical jump, visual reaction time, back and leg strength, flexibility, and balance tests. Each performance test was repeated twice, separated by a 3-minute passive rest interval, and the best score was recorded. Participants were instructed to refrain from eating within the three hours prior to performance testing. Immediately after each test session, the Borg Scale was used to assess perceived exertion. To assess delayed onset muscle soreness (DOMS), the Visual Analog Scale (VAS) was administered 24 hours after each session.

2.5. Data Analysis

Prior to selecting the statistical tests to be applied to the data, the Shapiro-Wilk normality test was conducted to assess whether the error terms were normally distributed ($p > 0.05$). Differences between variables were analyzed using repeated-measures ANOVA. Post-hoc comparisons between groups were evaluated using the Bonferroni correction. Effect sizes were calculated using the eta-squared (η^2) coefficient, ranging from 0.00 to 1.00, and interpreted as follows:

0.01 = small, 0.06 = medium, 0.14 = large, and 0.20 = very large (Alpar, 2022). The research findings were reported as mean and standard deviation (Mean ± SD), and statistical significance was set at a level of $p < 0.05$. All statistical analyses were conducted using the SPSS Statistics software package, version 22.0.

2.6. Ethical Approval

The necessary ethical approval for this study was obtained from the Sinop University Human Research Ethics Committee, with the decision dated 06.12.2024 and numbered 2024/404. All procedures were conducted in accordance with the principle of voluntary participation and adhered strictly to ethical standards. The research was carried out in line with the Directive on Scientific Research and Publication Ethics of Higher Education Institutions and the ethical principles of the Declaration of Helsinki. Prior to data collection, participants were fully informed about the purpose and procedures of the study and subsequently provided written consent.

3. Results

Table 1. Descriptive Characteristics

Variables	n	$\bar{X}$	SD	Min	Max
Age (year)	13	13.07	1.32	11.00	15.00
Training Age (years)	13	3.07	1.89	1.00	6.00
Height (cm)	13	1.60	0.11	1.40	1.76
Body Weight (kg)	13	51.07	11.96	31.00	70.00
BMI (kg/m²)	13	19.61	2.79	15.78	24.14

$\bar{X}$=Mean; SD= Standard Deviation; Min=Minimum; Max=Maximum; BMI=Body Mass Index

Table 2. Comparison of Performance Parameters Between Groups of Canoe Athletes

Variables	FR	DS	FR+DS	f	p	η^2
	$\bar{X}$±SD	$\bar{X}$±SD	$\bar{X}$±SD			
Vertical Jump (cm)	44.07±6.72	44.61±7.61	42.53±7.10	1.864	0.177	0.13
Anaerobic Power (watt)	750.32±199.93	757.71±202.84	742.27±206.73	0.656	0.528	0.05
Back Strength (kg)	126.88±201.41	73.34±21.29	72.11±16.98	0.935	0.353	0.07
Leg Strength (kg)	69.88±17.25	70.65±18.86	69.73±17.75	0.057	0.945	0.00
Flexibility (cm)	31.90±7.46	33.28±8.45	33.53±7.06	3.928	0.033*	0.25
Balance (p)	2.04±0.70	1.61±0.61	2.22±0.94	3.774	0.068	0.24

**(p<0,05); $\bar{X}$= Mean; SD= Standard Deviation; FR= Foam Rolling; DS= Dynamic Stretching*

According to the data presented in Table 2, a statistically significant difference was found between groups in the flexibility parameter ($p < 0.05$). In contrast, no statistically significant differences were observed in vertical jump (cm), anaerobic power, back and leg strength, or balance parameters ($p > 0.05$).

Table 3. Comparison of inter-group visual reaction times of canoe athletes

Variables	FR	DS	FR+DS	f	p	η^2
	$\bar{X}$±SD	$\bar{X}$±SD	$\bar{X}$±SD			
VRT	36.98±2.34	36.57±3.65	35.37±2.73	2.027	0.173	0.14
VRA	1.23±0.07	1.21±0.12	1.17±0.08	1.819	0.198	0.13
FVR	0.72±0.08	0.73±0.8	0.70±0.9	0.399	0.675	0.03
LVR	2.28±0.44	2.03±0.41	1.94±0.23	2.700	0.114	0.18
LVR	1.22±0.33	1.24±0.44	1.33±0.44	0.265	0.769	0.02

**(p<0,05); $\bar{X}$= Mean; SD= Standard Deviation; FR= Foam Rolling; DS= Dynamic Stretching; VRT= Visual Reaction Total; VRA= Visual Reaction Average; FVR= Fastest Visual Reaction; SVR= Slowest Visual Reaction; LVR= Last Visual Reaction*

According to the results presented in Table 3, no statistically significant differences were found between the groups in any of the visual reaction parameters ($p > 0.05$).

Table 4. Comparison of inter-group RPE and VAS parameters of canoe athletes

Variables	FR	DS	FR+DS	f	p	η²
	X̄±SD	X̄±SD	X̄±SD			
RPE	2.92±1.49	2.15±1.06	2.38±1.32	1.404	0.265	0.10
VAS	2.84±1.46	2.15±1.14	2.38±1.38	2.408	0.141	0.17

X̄=Mean; SD= Standard Deviation; FR= Foam Rolling; DS= Dynamic Stretching; RPE= Rate of Perceived Exertion; VAS= Visual Analog Scale

According to Table 4, no statistically significant differences were found in the RPE and VAS values of the canoe athletes ($p > 0.05$).

4. Discussion

This study aimed to investigate the acute effects of different warm-up protocols (FR, DS anad FR+DS) on various performance parameters. The test results revealed no statistically significant differences between groups in terms of vertical jump, anaerobic power, back and leg strength, balance, visual reaction time, RPE, and VAS values. However, a statistically significant difference was found in flexibility values between the FR and FR+DS groups. When these findings are compared with similar studies in the literature, it becomes evident that variations in methods, application durations, participant profiles, and assessment tools may have influenced the outcomes.

In our study, no statistically significant difference was observed in vertical jump performance between the groups. Meriçli and Tutar (2024) conducted a study with 13 female athletes to examine the effects of different warm-up protocols on vertical jump performance in volleyball players. They reported no statistically significant difference between pre- and post-test vertical jump values in the FR group. Güngör (2024), in a study involving 18 adolescent female volleyball players, found that DS warm-up protocols significantly improved vertical jump performance compared to the FR protocol. Richman et al. (2019) compared the effects of jogging+DS and DS+FR protocols on the performance of healthy female athletes and observed a significant improvement in vertical jump height (cm) in the DS+FR group compared to the jogging+DS group. Peacock et al. (2014), in a study comparing DS alone and DS+FR in male athletes, reported that the DS+FR group exhibited significantly greater improvements in vertical jump height than the DS-only group. Smith et al. (2018) investigated the acute effects of control, FR, DS, and FR+DS protocols on athletic performance. Vertical jump height was assessed every five minutes for 20 minutes following the intervention. The findings showed significant improvements in vertical jump height in the FR+DS group, particularly at the 15th minute, compared to the control group. When compared to the existing literature, the results of our study appear to be inconsistent. This discrepancy may be attributed to differences in protocol duration, participant characteristics (e.g., age, sex, training history), and the fact that our study focused solely on acute responses.

In our study, no statistically significant differences were found between groups in anaerobic power (W) values. In a study conducted by Yıldız et al. (2018), 21 university students underwent DS and DS+FR protocols two days apart. Anaerobic power was assessed using the Wingate cycling test following each protocol. The findings revealed that the DS+FR protocol produced significantly higher peak power and mean power values compared to the DS-only group. Lawton et al. (2016) investigated the effects of an FR+DS protocol (2*30 seconds) on anaerobic power in a study with 10 university students. They found no significant differences in vertical jump, broad jump, or 20 m sprint tests. Civan et al. (2023), in a study involving 16 combat sport athletes, evaluated 20 m sprint time and vertical jump performance by comparing dynamic+static stretching (DS+SS) with FR+DS+SS protocols. Their results indicated that while the DS+SS protocol was more effective for sprint time and jump height, the FR+DS+SS protocol showed superiority in terms of jump count. Although several studies in the literature have reported positive effects of FR and DS protocols on anaerobic power, such an effect was not observed in our study.

In contrast, our study did find a statistically significant difference in flexibility values among the groups. The highest flexibility values were recorded in the FR+DS warm-up protocol group. This outcome may be explained by physiological processes such as enhanced neural feedback mechanisms and increased blood flow to muscle and skin tissues, which are known to support greater range of motion. Güngör (2024) It was reported that the FR warm-up protocol was more effective than the traditional warm-up in increasing hip joint range of motion on both the right and left sides (Traditional warm-up: ROM right 99.29 ± 4.3; left 101.3 ± 5.1; FR warm-up: right 105.43 ± 6.2; left 106.71 ± 5.8).

Su et al. (2017), in a study involving 30 university students, found that the FR protocol improved flexibility more significantly than both static and dynamic stretching protocols. Hamada et al. (2024), in their study on 22 amateur male athletes, observed significant increases in range of motion following the application of an FR+DS protocol, indicating its acute positive effect on flexibility. In contrast, Peacock et al. (2014) compared DS and DS+FR (30 seconds) protocols in male athletes and reported no significant difference in flexibility between the groups. Likewise, Richman et al. (2019), found no significant difference in flexibility when comparing Jogging+DS and DS+FR protocols. Smith et al. (2018), in a study involving 29 university students, compared the acute effects of control, FR, DS, and FR+DS protocols on flexibility. According to the findings of the study, the sit-and-reach test results measured immediately after the FR application (3 × 30 seconds) were significantly higher compared to the control group. However, this improvement did not show a statistically significant difference when compared to the DS and FR+DS groups. Hsu et al. (2020), in a study involving 23 elite table tennis players, examined the acute effects of a DS+FR protocol on flexibility and found that the combination significantly improved flexibility. A review of the literature indicates that while the effects of FR on flexibility vary across studies, a considerable number of them report positive improvements in flexibility. This general trend is consistent with the findings of our study. Additionally, discrepancies in the literature may be attributed to several factors, including differences in application duration, the targeted muscle groups, participant profiles (athlete vs. sedentary), intensity of the intervention, the use of other warm-up methods before or after FR, individual factors such as pre-existing muscle-tendon stiffness or range of motion limitations, and variations in the timing of assessments.

In our study, no statistically significant differences were found between groups in terms of balance performance. Casado et al. (2025), in a study involving 22 male basketball players, reported significant improvements in balance performance following a three-month FR warm-up intervention. However, they noted that these gains were largely diminished one month after discontinuation of the protocol, with improvements maintained only in the anterior reach distances of both ankles (left and right). These findings highlight the importance of consistent application of FR for sustaining its positive effects on balance. Similarly, Seçer and Kaya (2021), in a study with 30 male football players, found that DS and DS+FR protocols did not produce significant improvements in dynamic balance, as measured by the Y-balance test. The lack of significant findings in our study regarding balance performance may be related to differences in the balance assessment method used, as well as the fact that our study focused exclusively on acute responses.

Additionally, no statistically significant differences were found between groups in terms of muscle strength values. Hamada et al. (2024) investigated the acute effects of the FR+DS protocol in a study involving 22 amateur male athletes. Their findings revealed significant increases in muscle strength following the intervention. These results suggest that the FR+DS protocol may contribute to athletic performance by simultaneously enhancing mobility and the strength of the targeted muscle groups. Hsu et al. (2020), in a study with 23 elite table tennis players, examined the acute effects of the DS+FR protocol on muscular strength. Their results showed that the combination significantly improved both lower extremity strength (measured by the broad jump test) and upper extremity strength (measured by the medicine ball throw test). These findings from the literature contradict the results of our study. This discrepancy may be attributed to differences in application duration, participant characteristics, and methods of strength assessment.

In our study, no statistically significant differences were found between groups in terms of visual reaction parameters. Seçer and Kaya (2025), in their study on football players, compared the effects of vibration foam rolling (VFR) and standard FR applications on lower extremity reaction time. They reported that VFR was significantly more effective than FR in improving reaction time. Similarly, Kuruma et al. (2013) investigated the effects of myofascial release (MR) on reaction time. Their findings showed significant reductions in both premotor time and reaction time in the quadriceps and hamstring groups following MR application. The findings in the literature are inconsistent, likely due to differences in the foam rolling warm-up protocols employed, which vary from the application method used in this study. This highlights a methodological diversity and a lack of standardization in the current literature, pointing to a gap that future research should aim to address.

In our study, no statistically significant differences were found between groups in terms of VAS scores. Several studies in the literature have examined the effects of FR on delayed onset muscle soreness (DOMS) resulting from exercise. For instance, Adamczyk et al. (2020) reported that post-exercise FR application resulted in significant and systematic reductions in pain levels assessed via the VAS at 24, 48, 72, and 96 hours. Similarly, in a review conducted by Hendricks et al. (2020), FR was found to be effective in reducing DOMS, with significant decreases in pain levels measured by VAS.

However, some studies have suggested that the effect of FR on DOMS may be comparable to that of passive rest, indicating that its effectiveness may vary depending on application duration, frequency, technique, and individual differences. In this context, it is important to note that in our study, FR was applied only as a part of the warm-up protocol, and pain levels were assessed only once, at 24 hours post-intervention. Therefore, due to differences in application methods and timing of measurements, direct comparison with studies in the existing literature involves certain limitations. Moreover, no study was found in the literature that specifically evaluated the effects of FR used as a warm-up protocol on delayed onset muscle soreness. In this regard, our study presents a novel and contributive approach to the current body of research.

In our study, no statistically significant differences were found between groups in terms of rate of perceived exertion (RPE) values. In a study conducted by Bibić et al. (2025) with young football players, foam rolling was used not as a warm-up protocol, but rather as a post-match recovery intervention. A 20-minute FR protocol was applied after competition, and its effects on RPE were assessed using the Borg Scale. Significant reductions in perceived exertion were observed at both 2 hours and 24 hours post-intervention. Upon reviewing the current literature, no studies were found that directly examined the effects of FR and DS protocols used as warm-up strategies on RPE. In this respect, our study helps to fill a gap in the literature and is considered to offer an original contribution to the field.

5. Conclusions

This study aimed to compare the acute effects of warm-up protocols involving DS, FR, and a combination of both on selected performance parameters in canoe athletes. The findings revealed that only the flexibility parameter showed statistically significant improvements following the FR+DS protocol, while no significant differences were observed in other performance measures.

In canoeing, range of motion is particularly critical for paddle efficiency during the pull phase. Therefore, improved flexibility may indirectly support technical performance and long-term musculoskeletal health. Additionally, inadequate flexibility levels can increase the risk of injury and negatively impact performance. In this context, the FR+DS combination protocol used in this study may be considered a safe and effective warm-up strategy for improving flexibility and potentially reducing injury risk in athletes.

The results of this study suggest that warm-up protocol selection should be guided by the specific performance parameter targeted. In sports where flexibility development is a priority, FR can be implemented either independently or in combination with DS. On the other hand, in terms of strength, balance, vertical jump, anaerobic power, and reaction time, the different warm-up protocols appear to produce similar acute effects.

Future research should be designed to include larger and more diverse athlete populations across different sports. It is also recommended to investigate different combinations of FR duration and intensity, and to conduct longitudinal studies that evaluate not only the acute but also the chronic effects of warm-up interventions.

Limitations

This study has several limitations. First, the participants had no prior experience with FR. This lack of familiarity may have limited the effectiveness of the intervention and prevented the full manifestation of its potential effects. Second, the sample was limited to young flatwater canoe athletes, which restricts the generalizability of the findings to athletes from different age groups or other sporting backgrounds. The FR protocol was applied for 2 × 20 seconds per muscle group, which may have been insufficient to elicit more pronounced musculoskeletal responses. The short duration of the application could partly explain the discrepancies between our results and those of other studies in the literature. Additionally, since this study focused exclusively on acute effects, it is not possible to draw conclusions about the long-term impacts of the applied warm-up protocols. Future studies should be conducted with larger and more diverse age groups, including athletes with varying training histories, and should incorporate longer intervention durations to enhance the generalizability and depth of understanding of the effects of FR and DS protocols.

Declaration: This study was presented as an oral presentation at the International Congress on Health, Tourism and Sports: Innovative Approaches Congress.

Author Contributions: Conceptualization: G.K. and Z.K.; Methodology: G.K., Z.K., and A.M.; Validation and Analysis: A.M. and F.K.; Investigation and Resources: G.K., Z.K., H.K., and A.M.; Writing – Original Draft: G.K., Z.K., H.K., and A.M.; Writing – Review & Editing: A.M. and F.K. All authors have read and approved the published version of the article.

Conflicts of Interest: The authors have declared no conflicts of interest.

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Informed Consent: Informed consent was obtained from all participants involved in the study.

Data Availability Statement The data are publicly available.

Abbreviations

FR	Foam Rolling
DS	Dynamic Stretching

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