

8-week additional sensomotoric warm-up drills improves motor performance and postural stability in high-performance female Rugby-7 players

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Purpose: The purpose of this study was to evaluate the effectiveness of a personalized training program to improve lower limb muscle strength and balance in professional female rugby 7 players. Given the strong association between postural stability, muscle strength and injury risk among athletes, and given the high incidence of injuries in rugby, preventive measures are warranted.

Methods: The study group consisted of 15 rugby 7s players (aged: 25.53 ± 4.58 years) who trained at least 3 times per week and had a minimum of 2 years of training experience. They underwent an 8-week training program (2 times per week) based on the FIFA-11 and Activate protocols. Anthropometric measurements, postural stability assessment using a stabilographic platform, and maximal muscle torque were measured in the participants.

Results: After completing the program, the players achieved significantly better values in static stabilographic indicators with closed eyes: overall stability index (OSI) ($P < .05$), anterior-posterior stability index (APSI) ($P < .01$), and medial-lateral stability index (MLSI) ($P < .01$). Additionally, dynamic indices at various levels of platform instability showed improvement: fall risk index (FRI12-6) ($P < .01$) and FRI6-2 ($P < .001$). An increase in the strength of the thigh extensors (right- R: $P = .001$; left- L: $P < .01$) and flexors (R: $P < .05$; L: $P < .05$) was also observed.

Conclusions: The standard training for rugby players should be supplemented with exercises from the proposed intervention to improve muscle strength and postural stability and thereby enhance proprioception.

Keywords: rugby, body balance, muscle strength, injury prevention program;

Introduction

Rugby Union is a widely popular team sport, with two teams competing on the field. The number of players per team can range from 7 to 15, depending on the version of the game. We distinguish variants of Rugby Union, such as Rugby League and the dynamic and spectacular Rugby 7s. The latter is characterized by a shortened match duration (2 x 7 minutes) and a reduced number of players—down to seven per team. The shorter match time contributes to the intensification of player actions¹. The game's dynamic changes in direction, intense physical clashes, and high physical demands put players at a heightened risk of various injuries². Over a 16-year period, around 11,000 injuries were recorded among professional rugby players, with an average of two players getting injured in each match³. Injuries most often occur in the head and lower limbs³. It is lower limb injuries that are among the most common. Primarily, the medial collateral ligament (MCL) and the anterior cruciate ligament (ACL) are affected³. These injuries lead to the longest recovery times, keeping players out of competition for extended periods⁴. It is worth noting that, using basketball as an example, women are five times more likely to suffer ACL injuries compared to men⁵. Similarly, in soccer, the occurrence of ACL injuries in women has been determined to be 3-6 times more frequent than in men⁶.

Research on the causes and costs of sports-related injuries across five sports disciplines in New Zealand (cricket, netball, rugby league, rugby union, and soccer) showed that during

the studied period, rugby union had the highest number of injury claims. The most effective method of injury prevention is training, which includes balancing the strength of different muscle groups⁷ and properly conducted warm-ups^{8,9}. An example of such a preventive program is FIFA 11 and FIFA 11+. It is a comprehensive set of exercises performed during warm-up to reduce the risk of injuries. The program focuses on improving muscle strength, balance, stability, coordination, and neuromuscular control¹⁰⁻¹³. Another program is the *Activate* program, which consists of balance exercises, strength exercises, movement control, and landing techniques, aimed at reducing the number of muscles, ligament injuries, and concussions in rugby players at various levels of experience¹⁴. However, it is a general warm-up program, not specifically aimed at preventing lower limb injuries, including those of the knee joint in soccer players.

The effectiveness of the above preventive programs likely results from the relationship between muscle strength, postural stability, and proprioception. Proprioception is the perception of stimuli generated within the body and refers to both the conscious and unconscious sense of postural stability, muscle control, and joint stability¹⁵. Proper proprioception reduces the risk of injury and improves quality of life, for instance, in cases of chronic instability^{7,16}. Moreover, training aimed at improving proprioception results in enhanced strength and balance^{17,18}. The literature also indicates that the above interventions prevent ankle sprains¹⁹ or ACL injuries^{18,20}. They demonstrated that there is a positive correlation between proprioception and both

static and dynamic balance, as well as between muscle strength and balance. Similarly, a correlation was shown between the strength ratio of knee joint extensors to flexors and postural stability¹⁸. There is also a relationship between the ability to maintain core stability, dynamic knee valgus, and the range of motion of the knee and ankle joints, and a higher risk of ACL injury in female athletes compared to male athletes²¹. Following this line of reasoning, female rugby 7 players who participated in the individually designed training program, which included strength, balance, and proprioceptive exercises, should show improvement in each of these parameters.

The current research results indicate the need for preventive measures among rugby players²². It is important to highlight that current scientific literature contains few studies on women participating in this sport, and most of them focus on injury rates rather than preventive strategies^{23,24}. Therefore, it is reasonable to attempt to develop a set of exercises that would improve muscle strength and postural stability parameters, which female athletes could additionally incorporate into their training cycle. This, in turn, would lead to improved proprioception in players. As mentioned, improving proprioception is one of the fundamental preventive measures that would result in a reduction in the number of injuries. Therefore, the aim of this study is to evaluate the effectiveness of a customized training program aimed at improving muscle strength and postural stability.

Material and methods

Participants

A total of 21 women were qualified for the study. The minimum required group size was set at $n=20$ with the assumptions of $\alpha=.05$; effect size $=.6$; test power $=.8$. The inclusion criteria were female gender, age 18-35 years, at least 2 years of rugby 7 training experience, and regular participation in training (at least 3 times a week). The players reported an average weekly training time of 7.97 ± 2.13 hours. Players younger or older than 18-35 years, those reporting less than 2 years of training experience, and those who had suffered upper or lower limb injuries preventing training within the 6 months preceding the study were excluded. All participants provided written consent to participate in the study. In consequence of injuries a total of fifteen players completed the full training program and the pre- and post-tests.

Procedure

The study evaluated 15 Rugby 7s players with a mean age of 25.5 years (± 4.58). Their average body mass was 69.58 kg (± 12.62), while the mean waist circumference (WC) and hip circumference (HC) were 77.27 cm (± 6.91) and 95.87 cm (± 7.29), respectively. The average body height of the players was 167.87 cm (± 6.32). All the measurements were performed after the participants were familiarized with the measurement protocol and completed a warm-up

Methods

Measurements of the maximum muscle strength moments for the hip, knee, and ankle joints were performed using the Maximum Voluntary Contraction (MVC) method on measurement equipment TBK3-P (JBA Staniak, Warsaw, Poland). Participants were instructed to exert maximal effort while pushing a bar or testing apparatus for 3 s. The participants were stabilized by a close-fitting roller at the level of the anterior iliac spine at the proximal part of the thigh and posteriorly at the lumbar spine. The upper limbs were crossed over the chest. The highest value (peak) was used for the statistical analysis. Finally, the absolute [$N \cdot m$] and relative to body mass [$N \cdot m \cdot kg^{-1}$] values of the

following parameters were analyzed.

Normalized values of muscle torque per body weight of each participant were obtained. Measurement positions were chosen in accordance with the producer's manual (sitting for hip flexors and knee extensors as well as foot flexors and extensors, prone position for hip extensors) with measurement readouts from mounted tensometric enhancer WPT 005 (JD Jarosław Doliński Systemy Mikroprocesorowe, Warsaw, Poland).

Stabilographic assessments were conducted to evaluate postural stability using the 950-440 System, Balance SD, 115 VAC Biodex Balance System SD platform by Biodex Medical Systems (Inc. New York, USA). Three protocols, each lasting 20 s with 10 s breaks, were implemented on the BBS. The Postural Stability Test (PST) was performed with starting position: standing, upper limbs along the torso, on the platform set to level 12 with eyes open (EO) and eyes closed (EC), and the following values were determined: Overall Stability Index (OSI), Anterior-Posterior Stability Index (APSI), and Medial-Lateral Stability Index (MLSI). The Fall Risk Test was performed with EO on the platform with increasing instability from level 12 to 6 and from 6 to 2 (level 12 being the most stable). Based on this, the Fall Risk Index (FRI) was determined.

Intervention

As part of the intervention, a customized training program Knee Armor Training (KAT) was designed to improve knee joint stability, balance, and muscle strength. The program lasted for 8 weeks, with sessions held twice a week for 45 minutes each. The exercises were divided into three main parts and were based on the "The FIFA 11", "FIFA 11+" and "Activate" programs²⁵⁻²⁸. To increase the effectiveness of the therapeutic intervention in terms of improving proprioception, some exercises were performed on an unstable surface^{29,30}. The first part consisted of the following exercises: ball throws performed on unstable surface (Fig. 1A), single-leg lunges onto a sensorimotor cushion (Fig. 1B), the single-leg clock exercise, where the athlete reaches out with the free leg toward various "clock" directions as indicated by the coach (Fig. 1C), and "Testing the partner" a single-leg balance challenges involving players pushing each other to challenge stability^{26,27} (Fig. 1D).

The second part of the intervention consisted of five exercises aimed at improving postural stability and plyometric performance. These exercises included: jumping with both feet in eight directions, changing direction each time based on the coach's signal (Fig. 1E), skip A drill (Fig. 1F), side-to-side jumps with weights (Fig. 1G), two-footed box jumps landing with a controlled squat (Fig. 1H) and lateral steps in a squat position, responding to verbal commands from the coach (Fig. 1I).

The final part of the intervention consisted of the following exercises: crab walks with resistance bands (Fig. 1J), Nordic hamstring curls for eccentric hamstring strength (Fig. 1K), side planks with hip raises (Fig. 1M), high side planks with leg adduction, on elevated support (Fig. 1L), single-leg hip hinge with a barbell (Fig. 1N), and assisted lower limb stabilization exercises, where a partner provided resistance in various directions (Fig. 1O-P)^{26,27,29}.

Changes in relation to FIFA 11, FIFA 11+, Activate:

1. Unstable surfaces: The inclusion of unstable surfaces aligns with proprioceptive training's goal of improving neuromuscular coordination and balance control, commonly found in both FIFA 11+ and Activate programs, where dynamic balance under challenging conditions is a key focus.
2. Plyometrics: Jumping in multiple directions and adding



Figure 1. Exercises of the Knee Armor Training (KAT) protocol.

coach-driven directional changes integrates dynamic balance and agility, similar to the change-of-direction drills seen in FIFA 11+. These kinds of exercises help improve reaction time and landing mechanics, both critical for injury prevention.

3. Single-leg movements: Exercises like the single-leg clock and single-leg hip hinge mirror proprioceptive drills that aim to increase core stability and control of the hip and knee joints, reducing the risk of ACL injuries, which is a focus in both injury prevention programs.
4. Resistance work: Using resistance bands in exercises like the crab walks and weight-based jumps, mirrors the eccentric strengthening principles of Activate and FIFA 11+, which aim to strengthen key stabilizer muscles (such as the glutes and hamstrings), crucial for reducing knee valgus and other injury-prone movements in athletes.

Statistical analysis

Statistical analysis was performed using the Statistica version 14 software by TIBCO Software Inc. Palo Alto, USA 2017. The normality of the variable distribution was assessed using the Shapiro-Wilk test. To evaluate the differences in the values of individual variables, a paired t-test and the Wilcoxon test were used. A significance level of $P \leq .05$ was adopted. For the analysis

of variance (ANOVA), eta squared (η^2) was used to measure the proportion of variance explained by the independent variable. Thresholds were defined as follows: for a small effect $\eta^2 \geq .01$; for a medium effect $\eta^2 \geq .06$; and for a large effect $\eta^2 \geq .14$.

Results

Following the intervention, significant improvements were observed in stabilographic parameters, indicating enhanced postural control and dynamic balance in professional female rugby 7s players. Specifically, reductions in static stabilographic indicators with eyes closed (EC) and dynamic indicators were evident. The Overall Stability Index (OSI) showed a significant reduction under EC conditions, with values decreasing from 3.2 to 1.7 (95% CI), a P -value of .027, and an η^2 of .302, indicating a moderate effect size. Similarly, the Anterior-Posterior Stability Index (APSI) improved significantly, with values decreasing from 2.9 to 1.3, accompanied by a P -value of .006 and an η^2 of .482, highlighting a strong effect size. Improvements were also observed in the Medial-Lateral Stability Index (MLSI), which decreased from 2.0 to 0.9, with a P -value of .009 and an η^2 of .417, reflecting a substantial effect size. Furthermore, the Fall Risk Index (FRI) demonstrated significant reductions under both the 12-6 ($P = .002$, $\eta^2 = .524$) and 6-2 ($P = .001$, $\eta^2 = .73$)

Table 1. Differences in stabilographic parameter values before and after the intervention

Parameters	Pre-tests			Post-test			P-value	F	η^2	
	mean±SD	Me	CI 95% [SI]	mean±SD	Me	CI 95% [SI]				
OSI	EO	.77±.46	.80	.52-1.03	.71±.19	.70	.6-.81	.60	.29	.20
	EC	2.97±2.28	3.20	1.71-4.23	1.68±.6	1.70	1.35-2.01	.03	6.07	.30
APSI	EO	.62±.39	.60	.41-.83	.56±.19	.60	.46-.66	.61	.27	.02
	EC	2.44±1.48	2.90	1.62-3.26	1.22±.36	1.30	1.02-1.42	<.01	13.06	.48
MLSI	EO	.35±.24	.40	.21-.48	.31±.12	.30	.24-.37	.53	.58	.04
	EC	1.89±1.31	2.00	1.17-2.62	1.01±.33	.90	.83-1.19	<.01	10.02	.42
FRI	12-6	1.26±.59	1.20	.93-1.59	.73±.2	.70	.61-.84	<.01	15.42	.52
	6-2	1.55±.7	1.40	1.16-1.94	.9±.35	.50	.71-1.09	<.01	37.39	.73

Legend 1. EO – eyes open; EC – eyes closed; OSI – Overall Stability Index; APSI – Anterior-Posterior Stability Index; MLSI – Medial-Lateral Stability Index; FRI – Fall Risk Index, platform instability levels, 12-6 more stable platform, 6-2 very unstable platform; Me – median, F – ratio of variance, SI – Stability Index unit.

= .727) conditions, indicating enhanced platform stability with very large effect sizes. These results suggest that the intervention was effective in improving postural stability and balance, particularly under conditions that challenge both dynamic and static control. Detailed data are presented in Table 1. The results are presented in SI (Stability Index units), as proposed by the device manufacturer.

A comparative analysis of the maximum muscle torques [Nm] normalized to the participants' body weight [kg] was performed before and after the intervention. Statistical analysis showed a significant increase in the strength of the thigh extensors. Detailed results are presented in Table 2 (Table 2).

The intervention resulted in significant improvements in muscle strength across specific lower limb muscle groups, particularly

Table 2. Differences in normalized muscle strength values for individual lower limb muscle groups, by body weight, before and after the intervention

Variables		Pre-tests			Post-test			P-value	F	η^2
		mean±SD	Me	CI 95%	mean±SD	Me	CI 95%			
Hip Extension [N·m·kg ⁻¹]	R	1.17±.46	1.15	.92-1.43	1.74±.51	1.79	1.45-2.02	.001	19.020	.576
	L	1.46±.59	1.55	1.14-1.79	1.98±.54	1.91	1.68-2.28	.014	7.937	.361
Hip Flexion [N·m·kg ⁻¹]	R	1.43±.32	1.35	1.26-1.61	1.71±.35	1.76	1.51-1.9	.027	6.229	.307
	L	1.34±.4	1.27	1.12-1.56	1.64±.37	1.69	1.43-1.85	.047	4.614	.247
Knee Extension [N·m·kg ⁻¹]	R	1.75±.31	1.77	1.58-1.92	1.86±.29	1.83	1.71-2.02	.340	.977	.065
	L	1.72±.34	1.78	1.54-1.91	1.64±.18	1.65	1.54-1.73	.397	.763	.051
Knee Flexion [N·m·kg ⁻¹]	R	1.22±.23	1.26	1.09-1.34	1.2±.19	1.19	1.1-1.3	.810	.059	.004
	L	1.27±.43	1.73	1.04-1.51	1.05±.23	1.05	.92-1.18	.068	3.916	.218
Foot extension [N·m·kg ⁻¹]	R	.74±.18	.77	.64-.84	.78±.2	.74	.67-.89	.488	.507	.034
	L	.82±.2	.83	.71-.93	.8±.19	.78	.69-.91	.729	.125	.008
Foot Flexion [N·m·kg ⁻¹]	R	2.42±.54	2.56	2.12-2.72	2.02±.71	1.86	1.63-2.42	.03	5.867	.295
	L	2.6±.46	2.64	2.34-2.84	1.92±.63	2.0	1.57-2.27	.001	16.440	.540

Legend 2. P – right; L – left; Me – median, F – ratio of variance.

in hip extension and foot flexion. Both the right and left limbs exhibited substantial gains in normalized hip extension strength, with P-values of .001 and .014, and effect sizes (η^2) of .576 and .361, indicating large to moderate improvements. For hip flexion, significant gains were observed in both limbs, with P-values of .027 and .047, and η^2 values of .307 and .247, reflecting medium to small effect sizes. However, no significant changes were found in knee extension strength for the right (P = .340) or left (P = .397) limbs. In knee flexion, the right limb showed no significant improvement (P = .810), while the left limb exhibited a marginal gain (P = .068) with a small effect size (η^2 = .218). Similarly, no significant differences were observed in foot extension for either limb (P = .488 and .729). In contrast, significant improvements were noted in foot flexion strength for both the right (P = .03) and left (P = .001) limbs, with large effect sizes (η^2 = .295 and .540), indicating substantial gains. These findings highlight the intervention's effectiveness in enhancing muscle strength in hip extension and foot flexion, though minimal or no improvements were noted in other areas.

Discussion

The conducted intervention showed that the 8-week of Knee Armor Training (KAT) custom training positively impacts muscle strength and postural stability in a group of professional rugby-7 players. It had a particularly significant effect on dynamic and static balance indicators with eyes closed. Moreover, there was a significant increase in the strength of thigh flexors and extensors, which regulate pelvic movements and help maintain postural stability. This indicates an improvement

in neuromuscular control from the central nervous system, and thus the effectiveness of the presented training.

Current literature mainly focuses on the preventive aspects of specialized training designed for professional rugby players²⁵. The use of the Activate program is an example of the long-term application of preventive training, as demonstrated by Attwood et al., who achieved a 40% reduction in lower limb injuries and a 60% reduction in concussions in the intervention group²⁸. Steffen et al. observed that the key to maximizing the benefits of specialized training is performing the intervention three or more times a week, which was associated with a 60% reduction in selected injuries^{12,23}. Currently, however, there are few reports confirming the effectiveness of the aforementioned interventions in improving muscle strength torques and postural stability in rugby players^{14,31}.

So far, it has been shown that strength (resistance) training brings many benefits for different population of patients and athletes^{32,33}. In addition to increasing muscle strength, strength training improves neuromuscular conduction³². Moreover, it stimulates the remodelling of ligaments and tendons, increases muscle endurance, enhances bone mass³³, and improves postural stability¹⁸.

The results showed a significant increase in the strength of the hip flexors and extensors in rugby 7 players. In the study of Lee et al. (2018) concluded that weakness in knee flexors may increase the risk of injury in this muscle group. In men, when the concentric strength of the knee flexors falls below 2.4 N m/kg, the risk of injury increases fivefold (P<.001). Additionally, when the ratio of concentric strength of the hamstring muscles

to the quadriceps falls below 50.5%, the risk of injury to the hamstring group increases more than threefold ($P < .01$)³⁴. Therefore, in the conducted studies, considering the preventive nature of the intervention, an attempt was made to assess the impact of the custom program on lower limb muscle strength and balance. On the other hand, after a 6-week training program, Cochrane, Harnett, and Pinfold in 2017 obtained different results to presented in this study. In their study, rugby players did not achieve an increase in muscle strength or greater activation of the muscles in the lower limb girdle ($P < .05$)³¹. According to the authors of the cited study, bodyweight exercises among professional athletes may not have been a sufficient stimulus to trigger adaptation in the musculoskeletal system.

The strength of the lower limb girdle muscles, particularly the hip extensors and rotators, is essential for maintaining pelvic stability³⁵. Therefore, the final set of exercises in our proposed training program focused on strengthening these muscles. According to the Krosshaug et al. 2007, women with weakened thigh extensors more often experience knee valgus during landing, including a greater dynamic knee valgus angle (DKV). It was found that if the DKV angle increases within 50 milliseconds of the initial ground contact, women have a fivefold higher chance of anterior cruciate ligament (ACL) injury compared to men ($P < .05$)⁵. On the other studies by Wan et al. (2021), participants engaged in training sessions three times a week for two months, focusing on flexibility and strengthening the hamstring muscles. In their program, individuals who underwent strength training showed a significant increase in muscle strength ($P < .001$) and an increase in hamstring length ($P < .05$)³⁶. In the other studies, Barengo et al. observed positive results after adding just two extra training sessions per week. However, the primary focus of their intervention was to reduce injury risk rather than to improve muscle strength itself^{5,35,37}. In the presented study, the athletes showed a decrease in the muscle strength of the foot flexors and extensors, with a significant result observed in the flexor strength (R: $P < .05$; L: $P < .01$). Other reports indicate that training twice a week for a period of 6 weeks resulted in a significant increase in ankle flexor strength ($P < .01$); however, the study group consisted of only 9 amateur male athletes. The strength parameters that showed significant improvements were the thigh flexors and extensors. However, it would be beneficial to consider incorporating exercises with external resistance, such as squats and deadlifts. Research suggests that performing strength exercises with progressively increasing external loads, ranging from 25% to 90% of body weight, leads to an increase in lower leg extensor strength ($P < .05$) and a significant improvement in maximal squat performance ($P < .001$)³⁸.

Notably, the rugby players showed significantly lower post-tests values in stabilographic parameters with eyes closed, including OSI, APSI, and MLSI, as well as in FRI 12-6 and FRI 6-2 with eyes open in compare to pretests. This indicates an improvement in postural stability, possibly due to training. Similar results were reported with relation of lower limb strength in climbers, paralleling improvements seen in Rugby-7 players³⁹. A study conducted one 16 elite players of premier football league, evaluated similar parameters following a 16-week intervention focused on proprioceptive exercises. These findings support the effectiveness of proprioceptive training in enhancing postural stability among professional athletes.

Research on the effects of using external loads to improve stability and, by extension, prevent injuries in women's rugby needs to be expanded. There is currently a lack of studies focusing on professional rugby players, with most available research addressing amateur athletes³⁸.

The primary limitations of this study include the absence of a control group, which confines the findings to a pilot study and limits the ability to attribute the observed changes directly to the intervention. This limitation arose from the practical necessity to address performance issues identified by the coach, making it impractical to divide the group into those needing and not needing the intervention. Additionally, the study did not evaluate specific skills such as sprints, directional changes, or ball handling, including tasks like catching and passing, as incorporating these assessments could have disrupted training and preparation. Furthermore, the performance assessment was conducted immediately after the KAT protocol, preventing an evaluation of the long-term sustainability of the observed benefits.

Practical Applications

The findings from this study indicate that incorporating a custom-designed training program focused on proprioception, muscle strength, and postural stability can significantly enhance performance and reduce injury risks for female rugby 7 players. Specifically, the exercises targeting hip flexors and extensors, as well as improving both static and dynamic balance, were shown to positively impact proprioception and neuromuscular control. To maximize these benefits, it is recommended that standard training routines for rugby players be expanded to include exercises from the custom program used in this study. The inclusion of these exercises can enhance hip stability, knee alignment, and overall balance, which are critical for reducing the occurrence of common injuries like ACL tears and lower limb strains.

Proprioceptive training, as demonstrated, also contributes to postural stability, potentially decreasing the dynamic knee valgus angle, which has been linked to higher risks of ACL injuries in female athletes. Therefore, this intervention could serve as a valuable addition to injury prevention strategies in women's rugby, and possibly other contact sports, to mitigate injury rates and promote long-term athletic performance.

Conclusions

The implementation of the customized training program enhances proprioception in rugby 7 players by increasing the strength of hip flexors and extensors, as well as improving postural stability in both static and dynamic conditions. Standard training for rugby players should be supplemented with exercises from this program to boost muscle strength and postural stability, thereby improving proprioception. This approach could help reduce the risk of the most common injuries in the sport.

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Ethical Committee approval

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

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The authors have no conflicts of interest to declare.

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Author-s contribution

K.J. and P.B. made substantial contributions to the conception and design of the work, while K.J., P.B., B.W., and M.S. contributed to data acquisition, analysis, and interpretation. Drafting and Critical Revision: The initial draft was prepared by K.J. and P.B., with critical revisions contributed by K.J., P.B., B.W., and M.S. to enhance intellectual content. Final Approval: All authors (K.J., P.B., B.W., and M.S.) provided final approval for the version to be published. Accountability and Integrity: Each author agrees to be accountable for all aspects of the work, ensuring the accuracy and integrity of all parts are thoroughly investigated and resolved.

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