applied sciences

MDPI

Article

Applying a Specific Warm-Up on Basketball Performance: The Basket-Up Approach

Julia Cerrillo-Sanchis [1], Ignacio Muñoz-Criado [1], Víctor Pérez-Puchades [1], Ignacio Palmero-Martín [1], Julio Galcerán-Ruiz [1], Rubén Portes-Sanchez [1], Iván Chulvi-Medrano [2], Fernando Domínguez-Navarro [3,4,*], Eva Morales-Hilario [1], Blanca Mur-Gomar [1], Sergio Calvache-Castillo [1], Vicente Sebastiá-Alcácer [1], Guillem Tortosa-Soriano [1], Pau Alcácer-Arraiza [1], Javier Bayarri-Melchor [1], Joan Martínez-Ortí [1], Adrián Valverde-García [1], Agustin Girbés-Melià [1], Josep Galán-Lliri [1], Marta Encarnación-Ramirez [1], César Ferrando-Porro [1], Pedro Cotolí-Suarez [1] and Borja Ricart-Luna [1]

[1] Alqueria Lab., Valencia Basket Club, 46013 Valencia, Spain; jcerrillo@valenciabasket.com (J.C.-S.); imunoz@valenciabasket.com (I.M.-C.); vperez@valenciabasket.com (V.P.-P.); ignaciopmartin@gmail.com (I.P.-M.); jgalceran@valenciabasket.com (J.G.-R.); rportes@valenciabasket.com (R.P.-S.); emorales@valenciabasket.com (E.M.-H.); bmur@valenciabasket.com (B.M.-G.); scalvache@valenciabasket.com (S.C.-C.); vsebastia@alqueriadelbasket.com (V.S.-A.); torto8@hotmail.com (G.T.-S.); palcacer@valenciabasket.com (P.A.-A.); jbayarri@valenciabasket.com (J.B.-M.); jmartinez@valenciabasket.com (J.M.-O.); avalverde@valenciabasket.com (A.V.-G.); agirbes@valenciabasket.com (A.G.-M.); josepegalan@hotmail.com (J.G.-L.); mencarnacion@valenciabasket.com (M.E.-R.); cesarferrando8@gmail.com (C.F.-P.); pcotoli@alqueriadelbasket.com (P.C.-S.); bricart@alqueriadelbasket.com (B.R.-L.)

[2] Research Group in Prevention and Health in Exercise and Sport (PHES), Department of Physical Education and Sports, University of Valencia, 46010 Valencia, Spain; ivan.chulvi@uv.es

[3] Biomechanics & Physiotherapy in Sports Research Group (BIOCAPS), Faculty of Health Sciences, Universidad Europea de Valencia, 46010 Valencia, Spain

[4] Department of Physiotherapy, University of Valencia, Calle Gascó Oliag 5, 46010 Valencia, Spain

* Correspondence: fernando.dominguez@uv.es

Abstract: This research aims to evaluate whether a basketball-specific warm-up (Basket-Up) provides immediate benefits in terms of the essential physical performance requirements of basketball and to compare these effects to those obtained from FIFA 11+. In total, 95 highly trained basketball athletes (49 women, 46 men), aged between 13 and 17, were randomly divided to either perform the FIFA 11+ program (n = 48) or the Basket-Up program (n = 47). Immediate evaluation encompassed the assessment of vertical jump (countermovement jump), agility (Lane Agility Test), and 20 m sprint. A two-way mixed analysis of variance was conducted with time (preintervention and postintervention), sex (men and women), and training group (FIFA 11+ and Basket-Up) as the within- and between-participant factors, respectively. Agility ($p < 0.001$, F = 66.759) and jumping ($p < 0.001$, F = 78.062) outcomes exhibited significant differences between pre- and postintervention values in both groups. Basket-Up agility values were significantly higher than those from FIFA 11+ ($p = 0.001$, F = 12.998). The implementation of a specific basketball warm-up program (Basket-Up) appears to be both safe and effective in enhancing immediate athletic performance among highly trained young basketball athletes. Moreover, the effects of this program are comparable to those obtained by a nonspecific basketball warm-up (FIFA 11+) in terms of sprint and jumping performance but demonstrate superiority in agility outcomes, favoring the Basket-Up program.

Keywords: warm-up; injury prevention; functional evaluation; basketball

Citation: Cerrillo-Sanchis, J.; Muñoz-Criado, I.; Pérez-Puchades, V.; Palmero-Martín, I.; Galcerán-Ruiz, J.; Portes-Sanchez, R.; Chulvi-Medrano, I.; Domínguez-Navarro, F.; Morales-Hilario, E.; Mur-Gomar, B.; et al. Applying a Specific Warm-Up on Basketball Performance: The Basket-Up Approach. *Appl. Sci.* **2024**, *14*, 5969. https://doi.org/10.3390/app14145969

Academic Editor: Stefano Masiero

Received: 19 May 2024
Revised: 25 June 2024
Accepted: 4 July 2024
Published: 9 July 2024

1. Introduction

Warm-up is considered an essential element in the athlete's daily routine, as it prepares them for the demands of training or competition [1]. The objective pursued is to increase

performance [2] and reduce the injury rate [3]. Diverse physical and physiological responses occur as a result of the performance of a warm-up, including increased muscle metabolism, improved biomechanics of muscle fibers, enhanced neuromuscular activation, elevated oxygen intake, and psychological preparation [2]. To achieve these adaptations, various training methodologies have been proposed, primarily categorized as passive or active warm-ups [4], with the latter further divided into general or sport-specific warm-ups based on the sport in question [5].

Specific warm-ups are characterized by recreating movements or situations as similar as possible to the usual practice. They aim to achieve a more effective neuromuscular preparation of the elements most involved in the practice [6]. Furthermore, recent evidence suggests that specific warm-ups may provide superior physical and performance effects due to their ability to simulate and/or replicate the stimuli that occur in the respective sport [7,8]. For basketball, specific physical and physiological demands are required, which are different from other sports disciplines, as it involves a high number of unilateral actions, changes in direction, rhythm, and explosive gestures [9]. Therefore, an optimal training activation in basketball should prepare athletes to properly perform these actions in order to achieve an adequate level of sports performance during practice, minimizing the risk of injury [1,10].

Based on these assumptions, specific warm-up protocols have been designed for sports disciplines such as football [11] or volleyball [12]. However, the current scientific literature lacks a specific pre-workout designed for basketball practice that covers its specific demands. In its absence, some of the other specific sports protocols (such as FIFA 11+) are sometimes used for basketball athletes, with conflicting evidence regarding its effectiveness. Some authors observed enhanced outcomes related to sports performance and reduced risk of injury when using FIFA 11+ as a warm-up program for basketball practice [13,14]. However, other studies did not find such benefits [15,16]. Furthermore, the effectiveness of FIFA 11+ has not been evaluated in comparison to a basketball-specific program. Therefore, it remains unknown whether a warm-up program tailored specifically for basketball may prepare athletes more efficiently. To attempt to elucidate this aspect, the first step may involve designing a specific basketball warm-up proposal and analyzing the effects produced immediately to avoid additional factors influencing the outcome. Subsequently, the analysis will extend to observe the effects over a longer period of time.

Consequently, this research aims to evaluate whether Basket-Up, a warm-up designed specifically for basketball, provides immediate benefits in terms of the essential physical performance requirements of basketball. The second aim is to analyze these effects in comparison to those obtained by performing the non-basketball-specific FIFA 11+ protocol. The hypothesis of this trial is the proposed Basket-Up warm-up protocol would enhance immediate performance outcomes similarly to or even more effectively than the FIFA11+ protocol.

2. Materials and Methods

2.1. Participants

In total, 95 young highly trained basketball athletes (aged between 13 and 18), including women (n = 49) and men (n = 46) from the Valencia Basket Club Academy, were recruited to participate in the study. These athletes came from 8 different competitive groups (4 female groups and 4 male groups), and each competitive group comprised 10–12 athletes. The evaluated academy athletes adhere to an elite formative methodology involving 4–5 weekly sessions of collective training, along with personalized physical conditioning training, and compete at the respective top local and national levels.

To be enrolled in the study, athletes had to meet the following inclusion criteria: (I) have participated in at least one basketball national competition during the last two years and (II) regular attendance at basketball practice throughout the season. Conversely, exclusion criteria were (I) current injury or complaint limiting sports activity; (II) history of injury requiring non-operative treatment in the last 3 months; and (III) history of injury requiring

operative treatment in the last 9 months. For those who met the inclusion criteria, both participants and parents/legal guardians gave their written informed consent to participate in the study, in accordance with the ethical guidelines of the Declaration of Helsinki and subsequent updates. This research adopted a randomized controlled trial design. The protocol was approved by the ethics committee of the University of Valencia (UV-INV_ETICA-3264539).

2.2. Procedures

Aligned with the study's objective, a randomized sequence was generated by computer software (www.randomizar.org) for each of the eight competitive groups to allocate participants to one of the two training groups: FIFA 11+ or Basket-Up warm-up. An external advisor, blinded to the performance of the interventions, was responsible for communicating the intervention group assignments to the participants. Consequently, the final sample comprised the following groups: FIFA 11+ n = 25 women; n = 23 men; Basket-Up n = 24 women; n = 23 men.

Both interventions were implemented simultaneously at the Alqueria del Basket facilities (Valencia, Spain), during the regular season. A strength and conditioning specialist, experienced in basketball, guided each respective warm-up program.

Two days before the implementation of the programs, athletes underwent an information and familiarization session specific to their respective interventions. This session involved the verbal explanation and the guided execution of exercises, overseen and corrected by the respective coach, to ensure athletes became acquainted with the protocols and achieved proper technical execution. No data registration was performed during the familiarization session.

Afterward, participants were scheduled based on the competitive groups (n = from 10 to 12) to perform either the FIFA 11+ or Basket-Up warm-up, according to the results of the randomization process. The interventions were carried out in February 2024, during the competition period. The coach who underwent the familiarization session for each group was responsible for guiding this performance session. Both programs started simultaneously and lasted for 20 min. During this period, no additional rest or food/water ingestion was allowed.

FIFA 11+ is a warm-up program developed by international experts under the direction of the FIFA Medical and Research Center (F-MARC) [17]. Its primary objective is to enhance performance and prevent injuries [3,6]. Consisting of fifteen exercises grouped into three parts, the program includes six running exercises in the first part; six exercises focusing on lower body strength, balance, and agility in the second part; and three running exercises to activate the cardiovascular system in the third part (Table 1). The program allows for progression, with three levels of performance exercises. For the current study, all participants performed level 1 exercises.

The Basket-Up warm-up program is crafted by a committee of experts comprising the performance department of the Valencia Basket Club. This protocol is specifically tailored to address the physiological, functional, and physical demands of basketball practice. Furthermore, it is designed to be performed in any sports facility, with no additional equipment. The proposed program adheres to the three-part structure of FIFA 11+, with three increasing levels of difficulty, and a total duration of 20 min. In this program, phase 1 consists of three exercises focused on mobility. The second part comprises six exercises concentrating on strength, changes in direction, and plyometrics. Finally, phase 3 involves six exercises oriented toward agility and neurocognitive tasks. A detailed description of the intervention is provided in Table 2. In terms of the manual and instructions, they are freely available on the official website (https://www.alqueriadelbasket.com).

Table 1. FIFA 11+ protocol.

Exercises	Repetitions
Running exercises	
Running straight ahead	2 reps
Running hip out	2 reps
Running hip in	2 reps
Running circling	2 reps
Running and jumping	2 reps
Running quick run	2 reps
Strength, Plyometrics, and Balance	
The plank (The bench)	
- Level 1: both legs	3 × 20–30 s
- Level 2: alternate legs	3 × 20–30 s
- Level 3: one-leg lift	3 × 20–30 s
Side plank (Sideways bench)	
- Level 1: static	3 × 20–30 s each side
- Level 2: dynamic	3 × 20–30 s each side
- Level 3: with leg lift	3 × 20–30 s each side
Nordic hamstring	
- Level 1	3–5 reps
- Level 2	7–10 reps
- Level 3	12–15 reps
Single-leg balance	
- Level 1: holding ball	2 × 30 s each leg
- Level 2: throwing ball with partner	2 × 30 s each leg
- Level 3: testing partner	2 × 30 s each leg
Squats	
- Level 1: with heles raised	2 × 30 s
- Level 2: walking lunges	2 × 30 s
- Level 3: testing partner	2 × 10 s each leg
Jumping	
- Level 1: vertical jump	2 × 30 s
- Level 2: lateral jump	2 × 30 s
- Level 3: box jump	2 × 30 s
Running exercises	
Running over pitch	3 reps
Bounding run	3 reps
Running and cutting	3 reps

Table 2. Basket-Up protocol.

Exercises	Repetitions
Mobility	
Ankle dorsiflexion	2 × 8 reps each side
Hip mobility	2 × 8 reps each side
The world's greatest stretch	2 × 8 reps each side
Strength, Changes in directions (CODs), and Plyometrics	
Core isometric lunge	
- Level 1: iso. lunge	2 × 20–30 s
- Level 2: iso. lunge with plantar flexion	2 × 20–30 s
- Level 3: iso. lunge landing	2 × 20–30 s
Hip lock	
- Level 1: hip lock	3 × 20–30 s each side
- Level 2: hip lock dynamic	3 × 20–30 s each side
- Level 3: hip lock with plantar flexion	3 × 20–30 s each side
Squats	
- Level 1: squat	3 × 20–30 s
- Level 2: lunge and squat lateral	3 × 20–30 s each side
- Level 3: single-leg squat	3 × 20–30 s each side
Hamstring	
- Level 1: hip hinge	3 × 20–30 s
- Level 2: hamstring bridge single leg (30°)	3 × 20–30 s each side
- Level 3: single-leg deadlift	3 × 20–30 s each side
Hip Turn	
- Level 1: hip turn	3 × 20–30 s each side
- Level 2: hip turn and crossover	3 × 20–30 s each side
- Level 3: crossover and shuffle	3 × 20–30 s each side
Jumping	
- Level 1: vertical jump	2 × 5 reps
- Level 2: bounds	2 × 5 reps each side
- Level 3: Hops	2 × 5 reps each side
Agility and Neurocognitive	
Running straight ahead	3 reps
Running circling partner	3 reps
Running quick forward and backward	3 reps
Running bounding	3 reps
COD defensive reaction	3 reps
COD auditive ball	3 reps

2.3. Outcome Assessment

In order to analyze the immediate effects of the interventions, outcome measurements were taken 1–2 min before the commencement of the warm-up session and 3–5 min after their completion. This frame was chosen to allow a brief period to mitigate the postintervention fatigue that could potentially hinder the assessment. Additionally, to avoid conducting preintervention outcome measurements in a deconditioned state, all athletes underwent a brief dynamic activation, following the principles designed by Faigenbaum et al. (2005). This activation lasted a total of 10 min and included dynamic mobility exercises and light aerobic activities.

2.4. Performance Variables

Outcome measurement was grounded in basketball performance variables and included agility, vertical jump, and sprint, performed in that order. The order remained consistently the same for all participants and was deliberately structured to minimize potential fatigue effects. All tests were conducted by two researchers not involved in the execution of the interventions and who were blinded to the participant's allocation.

To assess agility, the Lane Agility Test (LAT) was employed. Recognized as a basketball-specific test [18], it is included as one of the National Basketball Association (NBA) Draft Combine tests [19]. For the evaluation, four cones were positioned at the corners of a designated area on a basketball court. Players were required to navigate the circuit in the shortest time possible, incorporating sprints, lateral movements, and backward running. The time taken by each athlete to complete the course was recorded. Time was measured with a handheld manual chronometer. Each athlete made two attempts, with a 1 min rest interval between sets.

Jumping ability was measured through countermovement jump (CMJ). The test began with the subject standing on a platform, in the marked area, with their hands placed on their waist. Subsequently, the subjects were instructed to perform a vertical jump as high as possible by rapidly transitioning from knee and hip flexion to extension. The height reached in the jump was recorded with the Optojump jump platform (Microgate, Bolzano, Italy); this device has been validated [20]. Each athlete performed 3 jumps, leaving 30 s of rest between attempts.

Finally, the 20 m sprint test (Sprint 20 m) was used to evaluate speed. From a standing position with the dominant foot forward, the athlete had to run 20 m at maximum speed. Three photocells (Microgate® Polifemo Radio Light, Bolzano, Italy) were placed to record the athlete's time when passing the 20 m mark [21]. There were 2 attempts per athlete with a 1 min rest between attempts.

In each performance variable, the average of all attempts was used for subsequent analysis, differentiated between before and after the intervention.

2.5. Statistical Analyses

Statistical data analysis was conducted using SPSS v25 (Inc., Chicago, IL, USA). Descriptive analyses were performed for all evaluated outcomes, with mean values as a central measure of trend, and standard deviation (SD) was used as a measure of dispersion. The normality of the data distribution was analyzed with the Kolmogorov–Smirnov test, and homoscedasticity was analyzed with Levene's test.

For the inferential analysis, a two-way mixed analysis of variance (ANOVA) was conducted with the time (preintervention and postintervention), sex (men and women), age, and training group (FIFA 11+ and Basket-Up). For the non-normal distribution of the variables, the correspondent nonparametric analyses were performed. Effect size comparisons were determined using partial eta-squared (ηp^2), with the following interpretations: a ηp^2 value between 0.01 and 0.06 indicates a small effect. In contrast, a value between 0.06 and 0.14 indicates a medium effect, and a value greater than 0.14 indicates a large effect. The type I error was set at 5% ($p \leq 0.05$).

3. Results

A total of 95 athletes were evaluated, comprising 49 women (51.6%) and 46 men (48.4%), with a mean age of 15.63 years (SD = 1.72). Descriptive anthropometric and preintervention values for both men and women in the groups are outlined in Table 3, indicating no significant differences between groups ($p < 0.05$) before starting the interventions. All participants completed the intervention, and as a result, no adverse events directly related to either of the two warm-up programs were observed.

Table 3. Anthropometric and preintervention descriptive data of the participants (*n* = 95).

	Female (*n* = 49)			**Male (*n* = 46)**		
	FIFA 11+ (*n* = 25)	**Basket-Up (*n* = 24)**	***Between Groups***	**FIFA 11+ (*n* = 23)**	**Basket-Up (*n* = 23)**	***Between Groups***
	Mean (SD)	**Mean (SD)**	***p*-Values**	**Mean (SD)**	**Mean (SD)**	***p*-Values**
Anthropometric						
Age (years)	15.36 (1.63)	15.50 (1.79)	0.776	15.43 (1.59)	16.26 (2.66)	0.209
Height (cm)	173.90 (9.38)	167.58 (22.94)	0.210	187.50 (10.50)	188.22 (10.70)	0.818
Weight (kg)	65.08 (10.42)	65.39 (10.24)	0.919	77.13 (13.42)	76.92 (14.41)	0.959
Body mass index (kg/m^2)	21.42 (2.14)	26.01 (18.44)	0.223	21.75 (1.80)	21.51 (2.28)	0.691
Preintervention performance values						
LAT (s)	14.10 (0.74)	14.20 (0.92)	0.708	12.74 (1.00)	12.68 (0.70)	0.823
CMJ (cm)	26.78 (3.12)	27.33 (4.13)	0.605	36.29 (7.00)	37.30 (7.11)	0.622
Sprint 20 m (s)	3.64 (0.17)	3.63 (0.14)	0.813	3.29 (0.22)	3.25 (0.15)	0.509

LAT: Lane Agility Test; CMJ: countermovement jump.

All evaluated outcomes exhibited a normal distribution, except for CMJ ($p = 0.036$). Consequently, a Kruskal–Wallis analysis was performed for that variable.

The effects derived from the interventions, considering time, sex, and group interactions, are displayed in Table 4. Agility ($p < 0.001$, F = 66.759) and jumping ($p < 0.001$, F = 78.062) outcomes exhibited significant differences between pre- and postintervention values, indicating the effectiveness of both the Basket-Up and FIFA11+ programs in improving these outcomes in both genders.

Table 4. Effects derived from the interventions, considering time, sex, age, and group.

		Pre Values Mean (SD)	**Post Value Mean (SD)**	**Time Effect *p*-Values (F) (ηp^2)**	**Time × Sex Effect *p*-Values (F) (ηp^2)**	**Time × Age Effect *p*-Values (F) (ηp^2)**	**Time × Group Effect *p*-Values (F) (ηp^2)**	**Time × Group × Age Effect *p*-Values (F) (ηp^2)**	**Time × Group × Sex Effect *p*-Values (F) (ηp^2)**
LAT (s)									
Female	FIFA 11+	14.10 (0.75)	13.66 (0.58)	**$p < 0.001$ *** (66.759) (0.423)	**$p < 0.001$ *** (13.297) (0.127)	$p = 0.194$ (1.519) (0.092)	**$p = 0.001$ *** (12.998) (0.125)	$p = 0.958$ (0.103) (0.004)	$p = 0.100$ (2.755) (0.029)
	Basket-Up	14.20 (1.09)	13.58 (0.84)						
Male	FIFA 11+	12.74 (1.0)	12.77 (1.07)						
	Basket-Up	12.68 (0.69)	12.24 (0.63)						
CMJ (cm)									
Female	FIFA 11+	26.78 (3.11)	28.82 (3.39)	**$p < 0.001$ *** (78.062) (0.462)	$p = 0.327$ (0.969) (0.011)	$p = 0.186$ (1.545) (0.093)	$p = 0.309$ (1.046) (0.011)	$p = 0.646$ (0.556) (0.022)	$p = 0.909$ (0.013) (0.001)
	Basket-Up	27.33 (4.13)	28.95 (3.99)						
Male	FIFA 11+	36.29 (6.0)	38.84 (6.87)						
	Basket-Up	37.31 (6.01)	39.33 (7.63)						
Sprint 20 m (s)									
Female	FIFA 11+	3.63 (0.17)	3.63 (0.14)	$p = 0.608$ (0.265) (0.003)	**$p = 0.026$ *** (5.105) (0.053)	**$p = 0.004$ *** (3.763) (0.182)	$p = 0.277$ (1.194) (0.013)	$p = 0.758$ (0.394) (0.016)	$p = 0.910$ (0.013) (0.001)
	Basket-Up	3.25 (0.22)	3.58 (0.17)						
Male	FIFA 11+	3.29 (0.22)	3.34 (0.32)						
	Basket-Up	3.25 (0.15)	3.27 (0.24)						

LAT: Lane Agility Test; CMJ: countermovement jump; F: power; ηp^2: partial eta-squared; * indicates significant differences.

Furthermore, regarding agility, the Basket-Up program demonstrated superiority in enhancing this parameter compared to FIFA 11+, as evidenced by significant *p*-values for the time × group effect ($p = 0.001$, F = 12.998). Furthermore, this improvement was significantly greater among men, when considering the time × sex effect ($p < 0.001$, F = 13.297) but nonsignificant when observing the time × group × sex effect ($p = 0.100$; F = 2.755).

The jump ability yielded similar results in both warm-up programs (time × group effect: $p = 0.309$, F = 1.046). Additionally, CMJ values did not change differently among men and women (time × sex effect: $p = 0.327$, F = 0.969; time × group × sex effect: $p = 0.909$, F = 0.013).

In terms of sprint performance, both programs failed to show improved outcomes after the intervention, as indicated by nonsignificant time effects ($p = 0.608$, F = 0.265) and a lack of significant time × group interaction ($p = 0.277$, F = 1.194). Moreover, a worsening of performance (indicated by increased time spent on performing the test) was observed. However, the interaction effect between time and sex revealed significant values ($p = 0.026$, F = 5.105).

With regard to the effect of age, it was observed that it influenced the changes in sprint outcomes across the intervention ($p = 0.004$, F = 3.763), regardless of the group assigned ($p = 0.910$). No age effect was observed for jumping or agility.

4. Discussion

This study aimed to analyze whether a specific warm-up protocol (Basket-Up) may enhance immediate essential basketball performance (e.g., jump, sprint, and agility outcomes). Based on the obtained results, it was observed that the Basket-Up warm-up protocol had an overall positive effect, providing basketball athletes with a significant increase in performance in both jumping and agility. However, this program did not yield positive effects in terms of immediately improving the sprint ability of all participants. Additionally, this trial also aimed to analyze the effects in comparison to the outcomes obtained by a nonspecific basketball warm-up protocol (FIFA 11+). The immediate effects of Basket-Up were similar to those obtained by the FIFA 11+ program, especially in terms of jumping and sprinting, and appeared to be slightly better for agility, which will need further supporting evidence in future studies to establish the superior effects of this specific basketball program. Demonstrating the feasible and marginally superior effects of this program compared to FIFA supports the hypothesis proposed, confirming it overall.

Previous studies have analyzed the effect of different warm-ups on basketball players, reporting that a general warm-up program induces injury-reducing effects in the lower extremities [22]. However, evidence is lacking for studies analyzing the effects of a specific basketball warm-up in this sport. Specificity, in this context, warm-up can be defined as the recreation of training conditions that closely resemble those encountered during competition, employing stimuli that mirror real-game situations as closely as possible [23]. This approach aims to facilitate the transfer of conditioning gained from warm-up activities to subsequent competitive performance [2]. The specificity of the Basket-Up program lies mainly in the proper activation of the muscles in the lower limb, with functional gestures such as changes in direction, accelerations, and decelerations among others, which represent similar gestures to the demands that basketball athletes face in competition, as well as neurocognitive stimulus based on basketball practice.

To evaluate the effectiveness of the interventions, jumping, sprinting, and ability outcomes were chosen for the present study given their relevance to the specific performance demands of basketball [9].

The first specific parameter analyzed was agility. The agility values were observed to be greatly enhanced after the specific basket program in comparison to the nonspecific program, with no additional differences between men and women. Enhanced agility performance may be mainly explained by the specificity of the interventions, as well as by the greater neurocognitive exposure preparation observed in the Basket-Up program. Similarly, previous studies reported results showing improvements in agility performance with specific warm-up programs [24], which is aligned with our findings. Indeed, the FIFA 11+ program lacks basketball-specific agility movements, in contrast to the Basket-Up, which includes changes in direction as a result of reaction to basketball-specific environmental stimuli (e.g., auditory cues, defensive reactions, etc.). Therefore, it can be postulated that to enhance agility capacity in basketball athletes, including specific changes in direction

in their warm-up may improve performance, also considering the relevance of these maneuvers for the practice. Likewise, it may be taken into account that the test used in this research (LAT) is designed specifically for basketball [18].

Regarding jump performance, CMJ values improved similarly in both interventions, reflecting that a warm-up program that includes muscle activation may be sufficient to enhance this outcome in the immediate term, with no additional benefit for a specific program.

Conversely, sprint outcomes did not show significant improvement after either of the two interventions, with even worse sprint performance observed in some cases. However, different sprint effects were found according to the sex of the participants, but in no case did it evidence statistical improvement over time. This lack of improvement may be attributed to the immediate muscular fatigue resulting from the execution of the warm-up programs, which could diminish the muscle's capacity to execute a maximally demanding task, such as a 20 m sprint [25]. Similarly, Abdelkrim et al. [26] observed that the accumulated fatigue during basketball practice decreased the performance of high-speed actions. Furthermore, evidence suggests that basketball-practice-induced fatigue influences jump and sprint performance differently, which is consistent with our findings [27,28]. Considering the test used to evaluate sprint performance, the 20 m sprint was selected, in agreement with similar studies previously published. However, it remains unknown how the warm-up protocols may affect the performance of shorter sprint distances (e.g., 5 m, 10 m, etc.), which may be less impacted by fatigue. According to Bizzini et al. [17], basketball athletes might be more accustomed to managing this short-term fatigue.

Another factor that could explain these results is the dynamic warm-up conducted prior to the intervention, which may have already influenced speed ability. According to Faigenbaum et al. [7], a 10 min warm-up significantly enhanced performance in sprinting and jumping skills among non-athlete children. This suggests that dynamic warm-up likely exerts a direct influence on performance, potentially limiting further improvements in the abilities of the athletes during the intervention with both protocols.

The age of the participants is a crucial factor to consider when interpreting the results obtained. The sample comprised athletes aged from 13 to 18 years, suggesting that some may not have reached complete physiological maturity. Research has shown that the effects of physical exercise on physical condition vary depending on maturity stage [29], which may explain why age was found to significantly influence some of the evaluated outcomes. Calculating biological age using the peak height velocity (PHV) could provide further insights into the impact of this variable.

To summarize, the FIFA 11+ program was initially developed to address the specific demands of soccer, and consequently, its principles are primarily tailored to the requirements of this sport rather than other athletic disciplines. However, owing to its proven efficacy [6,30,31] and adaptability across various sports facility environments, and with different athlete skill levels, this program has garnered widespread acclaim within the sports community, prompting its implementation in other sporting realms beyond soccer. Precisely, diverse studies have corroborated its usefulness in other sports such as volleyball [32] or handball [33]. The significant improvement in sports performance after the FIFA 11+ program is linked to its intensity and the main objective of the program, which is to improve players' awareness of movement techniques and body alignments [34]. Furthermore, the research conducted by Sahin et al. [13] showed positive effects on agility among basketball athletes after the intervention. In contrast, Nuhmani et al. [15] found no additional effects on sprinting, agility, or vertical jump after 12 weeks of FIFA 11+.

The findings of the present study may contribute to addressing the existing knowledge gap concerning whether a specific basketball warm-up routine may yield superior effects compared to a nonspecific basketball program. Considering Basket-Up as an innovative warm-up proposal, the initial focus was on analyzing its immediate effectiveness while controlling for other potential variables that could influence the results, such as the intensity of technical–tactical training, individual players' competition time, accumulated fatigue, or perceived pains [35]. Likewise, one strength of the current study is the evalu-

ation's reliance on a relatively large sample size of highly trained athletes, all belonging to the same basketball club. This ensures consistency in practice routines and skill levels among participants.

However, a notable limitation of this study is that the observed effects are confined to the immediate evaluation after finishing the warm-up, leaving the potential effects over a follow-up period unexplored. Additionally, the effects were assessed after a single session, so further research should investigate the potential benefits over an extended program performance period.

5. Conclusions

The implementation of a specific basketball warm-up program (Basket-Up), which includes mobility exercises, functional muscle activation, and neurocognitive drills, appears to be safe and effective in enhancing immediate athletic performance among highly trained young basketball athletes. Moreover, the effects of this program on sprinting and jumping performance are comparable to those achieved with a nonspecific basketball warm-up (FIFA 11+), but it shows a slight advantage in agility outcomes. These findings suggest that a tailored basketball warm-up routine may be more suitable for competition preparation. However, further research analyzing longer program durations is necessary to fully understand the effectiveness of the Basket-Up program in both enhancing performance and preventing injuries.

Author Contributions: Conceptualization, all authors; methodology, I.C.-M., F.D.-N. and B.R.-L.; software, F.D.-N.; validation, I.C.-M. and B.R.-L.; formal analysis, J.C.-S.; investigation, all authors; data curation, B.R.-L. and I.C.-M.; writing—original draft preparation, J.C.-S., F.D.-N. and B.R.-L.; writing—review and editing, all authors; visualization, all authors; supervision, all authors; project administration, J.C.-S. and B.R.-L.; funding acquisition, I.C.-M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Universitat de València (UV-INV_ETICA-3264539, approved on 9 May 2024).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

Data Availability Statement: Data will be available upon reasonable request to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Alanazi, D.H.M. Role of Warming-up in Promoting Athletes Health and Skills. *Int. J. Sci. Res. Publ.* **2016**, *6*, 156.
2. McGowan, C.J.; Pyne, D.B.; Thompson, K.G.; Rattray, B. Warm-Up Strategies for Sport and Exercise: Mechanisms and Applications. *Sports Med.* **2015**, *45*, 1523–1546. [CrossRef] [PubMed]
3. Silvers-Granelli, H.; Mandelbaum, B.; Adeniji, O.; Insler, S.; Bizzini, M.; Pohlig, R.; Junge, A.; Snyder-Mackler, L.; Dvorak, J. Efficacy of the FIFA 11+ Injury Prevention Program in the Collegiate Male Soccer Player. *Am. J. Sports Med.* **2015**, *43*, 2628–2637. [CrossRef] [PubMed]
4. Bishop, D. Warm Up II. *Sports Med.* **2003**, *33*, 483–498. [CrossRef]
5. Woods, K.; Bishop, P.; Jones, E. Warm-Up and Stretching in the Prevention of Muscular Injury. *Sports Med.* **2007**, *37*, 1089–1099. [CrossRef] [PubMed]
6. Neto, M.G.; Conceicao, C.S.; de Lima Brasileiro, A.J.A.; de Sousa, C.S.; Carvalho, V.O.; de Jesus, F.L.A. Effects of the FIFA 11 training program on injury prevention and performance in football players: A systematic review and meta-analysis. *Clin. Rehabil.* **2017**, *31*, 651–659. [CrossRef] [PubMed]
7. Faigenbaum, A.D.; Bellucci, M.; Bernieri, A.; Bakker, B.; Hoorens, K. Acute effects of different warm-up protocols on fitness performance in children. *J. Strength Cond. Res.* **2005**, *19*, 376. [PubMed]
8. Trajković, N.; Gušić, M.; Molnar, S.; Mačak, D.; Madić, D.M.; Bogataj, Š. Short-Term FIFA 11+ Improves Agility and Jump Performance in Young Soccer Players. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2017. [CrossRef]

9. Vázquez-Guerrero, J.; Ayala, F.; Garcia, F.; Sampaio, J. The Most Demanding Scenarios of Play in Basketball Competition From Elite Under-18 Teams. *Front. Psychol.* **2020**, *11*, 552. [CrossRef]
10. Longo, U.G.; Loppini, M.; Berton, A.; Rizzello, G.; Marinozzi, A.; Maffulli, N.; Denaro, V. The FIFA 11+ Programme is Effective in Preventing Injuries in Elite Male Basketballers: A Cluster Randomised Controlled Trial. *Arthroscopy* **2013**, *29*, e112–e113. [CrossRef]
11. Bizzini, M.; Dvorak, J. FIFA 11+: An effective programme to prevent football injuries in various player groups worldwide—A narrative review. *Br. J. Sports Med.* **2015**, *49*, 577–579. [CrossRef] [PubMed]
12. Pérez López, A.; Valadés Cerrato, D. Physiological Basis of Volleyball Warm-Up: Practical Proposal. Bases fisiológicas del calentamiento en voleibol: Propuesta práctica. *Cult. Cienc. Deporte* **2013**, *8*, 31–40. [CrossRef]
13. Sahin, N. The effect of comprehensive warm up (fifa 11+ program) on motor abilities in young basketball players: A pilot study. *Acta Medica Mediterr.* **2018**, *34*, 703–707. [CrossRef]
14. Longo, U.G.; Loppini, M.; Berton, A.; Marinozzi, A.; Maffulli, N.; Denaro, V. The FIFA 11+ Program Is Effective in Preventing Injuries in Elite Male Basketball Players: A Cluster Randomized Controlled Trial. *Am. J. Sports Med.* **2012**, *40*, 996–1005. [CrossRef] [PubMed]
15. Nuhmani, S. The FIFA 11+ does not alter performance in amateur female basketball players—A randomized control trial. *J. Complement. Integr. Med.* **2021**, *18*, 379–383. [CrossRef] [PubMed]
16. Slauterbeck, J.R.; Choquette, R.; Tourville, T.W.; Krug, M.; Mandelbaum, B.R.; Vacek, P.; Beynnon, B.D. Implementation of the FIFA 11+ Injury Prevention Program by High School Athletic Teams Did Not Reduce Lower Extremity Injuries: A Cluster Randomized Controlled Trial. *Am. J. Sports Med.* **2019**, *47*, 2844–2852. [CrossRef] [PubMed]
17. Bizzini, M.; Impellizzeri, F.M.; Dvorak, J.; Bortolan, L.; Schena, F.; Modena, R.; Junge, A. Physiological and performance responses to the "FIFA 11+" (part 1): Is it an appropriate warm-up? *J. Sports Sci.* **2013**, *31*, 1481–1490. [CrossRef] [PubMed]
18. Stojanović, E.; Aksović, N.; Stojiljković, N.; Stanković, R.; Scanlan, A.T.; Milanović, Z. Reliability, Usefulness, and Factorial Validity of Change-of-direction Speed Tests in Adolescent Basketball Players. *J. Strength Cond. Res.* **2019**, *33*, 3162. [CrossRef]
19. Simenz, C.J.; Dugan, C.A.; Ebben, W.P. Strength and conditioning practices of national basketball association strength and conditioning coaches. *J. Strength Cond. Res.* **2005**, *19*, 495.
20. Glatthorn, J.F.; Gouge, S.; Nussbaumer, S.; Stauffacher, S.; Impellizzeri, F.M.; Maffiuletti, N.A. Validity and Reliability of Optojump Photoelectric Cells for Estimating Vertical Jump Height. *J. Strength Cond. Res.* **2011**, *25*, 556. [CrossRef]
21. Padulo, J.; Bragazzi, N.L.; Nikolaidis, P.T.; Dello Iacono, A.; Attene, G.; Pizzolato, F.; Dal Pupo, J.; Zagatto, A.M.; Oggianu, M.; Migliaccio, G.M. Repeated Sprint Ability in Young Basketball Players: Multi-direction vs. One-Change of Direction (Part 1). *Front. Physiol.* **2016**, *7*, 133. [CrossRef] [PubMed]
22. LaBella, C.R.; Huxford, M.R.; Grissom, J.; Kim, K.-Y.; Peng, J.; Christoffel, K.K. Effect of Neuromuscular Warm-up on Injuries in Female Soccer and Basketball Athletes in Urban Public High Schools: Cluster Randomized Controlled Trial. *Arch. Pediatr. Adolesc. Med.* **2011**, *165*, 1033–1040. [CrossRef] [PubMed]
23. Marques, N.K. Specificity principle applied in the volleyball. *MOJ Sports Med.* **2020**, *4*, 13–15. [CrossRef]
24. Andrade, D.C.; Henriquez-Olguin, C.; Beltran, A.R.; Ramirez, M.A.; Labarca, C.; Cornejo, M.; Alvarez, C.; Ramirez-Campillo, R. Effects of general, specific and combined warm-up on explosive muscular performance. *Biol. Sport* **2015**, *32*, 123–128. [CrossRef] [PubMed]
25. Ayala, F.; Pomares-Noguera, C.; Robles-Palazón, F.J.; Del Pilar Garcia-Vaquero, M.; Ruiz-Pérez, I.; Hernández-Sánchez, S.; Croix, M.D.S. Training Effects of the FIFA 11+ and Harmoknee on Several Neuromuscular Parameters of Physical Performance Measures. *Int. J. Sports Med.* **2017**, *38*, 278–289. [CrossRef]
26. Ben Abdelkrim, N.; Castagna, C.; Jabri, I.; Battikh, T.; El Fazaa, S.; Ati, J.E. Activity Profile and Physiological Requirements of Junior Elite Basketball Players in Relation to Aerobic-Anaerobic Fitness. *J. Strength Cond. Res.* **2010**, *24*, 2330. [CrossRef] [PubMed]
27. Castagna, C.; Abt, G.; Manzi, V.; Annino, G.; Padua, E.; D'Ottavio, S. Effect of Recovery Mode on Repeated Sprint Ability in Young Basketball Players. *J. Strength Cond. Res.* **2008**, *22*, 923. [CrossRef]
28. Philipp, N.M.; Cabarkapa, D.; Eserhaut, D.A.; Yu, D.; Fry, A.C. Repeat sprint fatigue and altered neuromuscular performance in recreationally trained basketball players. *PLoS ONE* **2023**, *18*, e0288736. [CrossRef]
29. Pichardo, A.W.; Oliver, J.L.; Harrison, C.B.; Maulder, P.S.; Lloyd, R.S.; Kandoi, R. The Influence of Maturity Offset, Strength, and Movement Competency on Motor Skill Performance in Adolescent Males. *Sports* **2019**, *7*, 168. [CrossRef]
30. Asgari, M.; Nazari, B.; Bizzini, M.; Jaitner, T. Effects of the FIFA 11+ program on performance, biomechanical measures, and physiological responses: A systematic review. *J. Sport Health Sci.* **2023**, *12*, 226–235. [CrossRef] [PubMed]
31. Impellizzeri, F.M.; Bizzini, M.; Dvorak, J.; Pellegrini, B.; Schena, F.; Junge, A. Physiological and performance responses to the FIFA 11+ (part 2): A randomised controlled trial on the training effects. *J. Sports Sci.* **2013**, *31*, 1491–1502. [CrossRef] [PubMed]
32. Hosseini, M.S.; Rajabi, R.; Minoonejad, H.; Barati, A.H. Effect of Eight Weeks of FIFA 11+ Training on the Agility and Explosive Power of Male College Volleyball Players. *Ann. Mil. Health Sci. Res.* **2019**, *17*, e97233. [CrossRef]
33. Abedinzadeh, S.; Sahebozamani, M.; Amirseyfaddini, M.; Abbasi, H. Effect of 8 weeks of injury prevention training of modified fifa 11+ on kinetics indices of vertical jump on elite handball players. *Pharmacophore* **2017**, *8*, e-1173382.

34. Steffen, K.; Emery, C.A.; Romiti, M.; Kang, J.; Bizzini, M.; Dvorak, J.; Finch, C.F.; Meeuwisse, W.H. High adherence to a neuromuscular injury prevention programme (FIFA 11+) improves functional balance and reduces injury risk in Canadian youth female football players: A cluster randomised trial. *Br. J. Sports Med.* **2013**, *47*, 794–802. [CrossRef] [PubMed]
35. Behrens, M.; Gube, M.; Chaabene, H.; Prieske, O.; Zenon, A.; Broscheid, K.-C.; Schega, L.; Husmann, F.; Weippert, M. Fatigue and Human Performance: An Updated Framework. *Sports Med.* **2023**, *53*, 7–31. [CrossRef] [PubMed]