

# Effects of a Short-Duration Interval Cycling Re-Warm-Up on the Performance of Basketball Substitutes

Christos Koutsouridis<sup>1</sup>, Christos Galazoulas<sup>1</sup>, Vasiliki Manou<sup>1</sup>, Nikolaos Stavropoulos<sup>1</sup>, Georgios Karamousalidis<sup>1</sup>

## AFFILIATIONS

<sup>1</sup>Aristotle University of Thessaloniki, School of Physical Education & Sport Science, Department of Physical Education & Sport Science, Thessaloniki, Greece

## CORRESPONDENCE

**C. Koutsouridis**, Aristotle University of Thessaloniki, School of Physical Education & Sport Science, Department of Physical Education & Sport Science, Laboratory of Evaluation of Human Biological Performance, Themi, DPES AUTH, 57001 Thessaloniki, Greece, [koutsouridisc@gmail.com](mailto:koutsouridisc@gmail.com)

## Abstract

The manuscript investigates whether a short, highintensity interval cycling re-warm-up (RWU) can mitigate the performance decline observed in basketball substitutes after passive bench rest. Thirteen semi-professional male basketball players participated in a within-subjects crossover design consisting of two experimental conditions (CON and RWUint), performed on separate days in a counterbalanced order. In the control condition, athletes completed 15 minutes of passive rest following a standardized warm-up, whereas in the experimental condition (RWUint), they completed 13.5 minutes of rest followed by three 5-second maximal cycling sprints at 7.5% of their body mass, separated by 25-second recovery intervals. In both conditions, athletes rested for one additional minute before the subsequent measurements. Performance outcomes included the countermovement jump (CMJ) and the modified agility T-test (MAT), while physiological variables (heart rate and body temperature) and subjective perceptions, rating of perceived exertion (RPE) and perceived readiness to return (PRR), were also assessed. The findings demonstrated smaller declines in CMJ ( $p < 0.001$  in CON;  $p = 0.005$  in RWUint) and MAT performance ( $p = 0.03$  in CON;  $p = 0.56$  in RWUint) under the RWUint condition than in passive rest, as well as reduced reductions in heart rate and body temperature ( $p < 0.001$ ). Although RPE slightly increased ( $p = 0.150$ ) and PRR remained stable ( $p = 0.303$ ) following RWUint, both parameters deteriorated during passive rest ( $p = 0.003$  and  $p < 0.001$ , respectively). The authors conclude that brief, highintensity interval re-warm-up sessions effectively preserve physiological readiness and neuromuscular performance, offering a practical, time-efficient strategy for basketball substitutes during competition.

**Keywords:** re-warm-up, basketball performance, substitute players, cycle ergometer, agility, jump performance

## Introduction

Basketball is an intermittent team sport, combining high-intensity actions with recovery periods (Abian-Vicen et al., 2014). Basketball-specific movements, such as sprinting and jump-ing, play a critical role in scoring outcomes (Hoffman et al., 1996), and a proper warm-up (WU) is considered a crucial part of an athlete's routine prior to training or the game, preparing them for these athletic demands (Alanazi, 2016). Player substitutions are also important because they allow coaches to influence and alter the game's dynamics

and overall team performance (Clay & Clay, 2014), helping to manage players' fatigue and maintain performance levels throughout the game.

According to the FIBA rules (FIBA, 2024), a team may use twelve players in a game, of whom seven must remain seated at all times. In previous studies, a passive period on the bench led to a significant drop in body temperature of the athletes (Koutsouridis et al., 2025), a relatively fast decline in jumping and running performance (Galazoulas et al., 2012), and an overall decrease in physical performance that impairs neuromuscular function (González-Devesa et al., 2021). This

cooling effect, which is similar to what football players experience during halftime, slows reaction times and reduces muscle power, ultimately contributing to a decline in game-specific sharpness that adversely impacts decision-making and reaction efficiency (Edholm et al., 2015). Furthermore, the decrease in body temperature not only impairs performance but also increases the risk of injury during this crucial phase of the game, which requires significant locomotor effort (Mohr et al., 2004).

Although several studies have examined re-warm-up (RWU) protocols during halftime in sports, there is no consensus on the optimal approach (González-Devesa et al., 2021). In the context of basketball, and specifically during in-game passive periods, the available research remains limited. The first study to our knowledge (Alberti et al., 2014) examined how prolonged sitting affects vertical jump performance in young basketball players and found that 20 minutes of sitting after WU significantly reduced jump height. This effect occurred even when seated players performed activities like foot tapping or lower back mobilization, though a 2-minute activity recovered performance to post-WU levels. In two more recent studies (Koutsouridis et al., 2024; Koutsouridis et al., 2025), a 15-minute period of passive rest resulted in a decline in performance, as shown by reduced outcomes in the countermovement jump (CMJ) and modified agility T-test (MAT). Additionally, physiological factors such as body temperature (BT) and heart rate (HR) significantly decreased, while perceived exertion (RPE) and perceived readiness (PRR) were also negatively impacted. However, a 3-minute moderate-intensity (Koutsouridis et al., 2024) and a 1-minute high-intensity (Koutsouridis et al., 2025) RWU protocol on a cycle ergometer appeared to be effective practices in mitigating these losses. Specifically, both protocols yielded improved results across all six previously mentioned factors compared to passive rest, suggesting that athletes were better prepared

for optimal performance without requiring a transitional phase to regain the WU benefits.

Given the limited research on in-game basketball studies, this study aims to investigate the effects of an alternative RWU protocol permissible by FIBA rules. Specifically, the purpose of this research is to determine whether an interval RWU protocol on a cycle ergometer can improve players' performance compared to passive rest on the bench. We hypothesized that the interval RWU protocol can mitigate the negative effects of passive rest and that the performance of substitute players who undergo this protocol would improve compared to those who remain seated for 15 minutes.

## Materials and methods

### Subjects

The required number of participants was estimated using G\*Power 3.1, based on prior findings by Koutsouridis et al. (2025), where the effects of a high-intensity RWU protocol were investigated on athletic performance in basketball players who remained in passive rest following the WU. The sample size calculation used an effect size (ES) of 1.0, an  $\alpha$ -level of 0.05, and a statistical power of 0.812, resulting in a minimum sample of 10 athletes. For this study, 13 semi-professional basketball players (mean age = 20.46 ± 1.33 years) were recruited. Participant characteristics are shown in Table 1. All participants were healthy, with an average training experience of 9.08 years, and reported no musculoskeletal injuries during the last six months. Written consent was obtained from all individuals following a detailed explanation of the study's purpose, procedures, and potential risks. The study protocol was approved by the local ethics committee (Approval number 132/2022) and was conducted in accordance with the Declaration of Helsinki.

**Table 1.** Characteristics of the participants (mean ± SD)

	Mean ± SD
Age (years)	20.46±1.33
Training Age (years)	9.08±2.06
Trainings per week	4.08±1.12
Body mass (kg)	81.13±5.67
Height (m)	1.84±0.06
BMI (kg/m <sup>2</sup> )	24.11±1.86
Body Fat (%)	12.22±3.97
VO <sub>2</sub> max (ml/min/kg)	50.69±4.24
Watts at VO <sub>2</sub> max	296.00±16.97
7.5% of BM (kg)	6.08±0.43
Resting HR (bpm)	75.71±11.14
HRmax (bpm)	188.23±5.42
Resting Body Temperature (°C)	36.13±0.36

Note. BM – body mass; BMI – body mass index; bpm – beats per minute; HR – heart rate; VO<sub>2</sub>max – maximum oxygen uptake.

## Design

During an initial laboratory visit, participants underwent an assessment of their maximal oxygen uptake ( $\text{VO}_2\text{-max}$ ). Afterwards, each participant took part in two experimental trials, scheduled in a randomized, counterbalanced order using a repeated-measures design. The two trials were conducted 24 hours apart. In both, athletes completed a standardized basketball warm-up (WU), followed by one of the two RWU conditions. The control condition (CON) involved 15 minutes of passive rest, while the experimental condition (RWU<sub>int</sub>) consisted of 13.5 minutes of passive rest and three sets of 5-second cycling sprints at maximum effort against a resistance equivalent to 7.5% of body mass, each separated by 25 seconds of passive recovery. In both conditions, ath-

letes rested for one additional minute before the subsequent measurements. Performance and physiological variables were measured at two time points: immediately after the WU (post-WU) and following the respective RWU protocol (post-RWU). The measured variables included two physiological indicators (HR and BT), two objective performance metrics (CMJ and MAT), and two subjective assessments (RPE and PRR). An overview of the study protocol is shown in Figure 1.

Participants were asked to maintain their usual training routines, diet, and daily habits throughout the study period. To ensure dietary consistency, they documented all meals and drinks consumed the day before each trial and replicated the same intake prior to the following session. Consumption of alcohol and caffeine was restricted for 24 hours before testing. During all sessions, water intake was permitted ad libitum.

	27-min	5-min	15-min	5-min
<b>CON</b>	General WU (7.5-min) Stretching (8.5-min) Specific WU (11-min)	RPE, PRR, HR, BT, CMJ, MAT	Passive Rest	RPE, PRR, HR, BT, CMJ, MAT
<b>RWU<sub>int</sub></b>	General WU (7.5-min) Stretching (8.5-min) Specific WU (11-min)	RPE, PRR, HR, BT, CMJ, MAT	13.5-min rest + 3x (5-s max effort with load 7.5% BM + 25-s rest) + 1-min rest	RPE, PRR, HR, BT, CMJ, MAT

**Figure 1.** Study Protocol

Note. BM – body mass; BT – body temperature; CMJ – counter movement jump; CON – control group; HR – heart rate; MAT – modified agility T-test; PRR – perceived readiness rating; RPE – rating of perceived exertion; RWU<sub>int</sub> – interval re-Warm up; WU – warm up.

## Procedures

Participants completed preliminary assessments during this period, including height, body mass, body fat percentage, and  $\text{VO}_2\text{max}$ . The latter was determined using a graded exercise test on a cycle ergometer (80 rpm cadence), starting at 1.2 kg (96 W) for 3 minutes and increasing to 1.9 kg (152 W) for another 3 minutes, followed by increases of 0.3 kg/min until exhaustion.  $\text{VO}_2$  was recorded breath-by-breath with an AE-310s gas analyzer (Minato Medical Science, Japan), and  $\text{VO}_2\text{max}$  was confirmed if at least two of the following were observed: 1)  $\text{VO}_2$  plateau, 2)  $\text{HR} > 90\%$  of predicted max (220-age), and 3) respiratory exchange ratio  $> 1.05$ .

To ensure familiarity, participants performed familiarization trials twice. Testing was then conducted across two consecutive days (24-hour interval), with each session beginning at the same time of day ( $\pm 15$  minutes) to minimize circadian variation. The indoor basketball court conditions averaged  $17.1^\circ\text{C} \pm 1.5^\circ\text{C}$  and  $46.7\% \pm 4.3\%$  humidity.

The athletes were randomly assigned to two groups. On the first day, one group performed the CON condition, while the other completed the RWU<sub>int</sub> protocol; the protocols were reversed between groups on the second day to counterbalance potential order effects. Each session started with a standardized basketball WU (Galazoulas et al., 2012), followed by post-WU measurements. Participants then completed the

assigned experimental protocol, after which the post-RWU assessments were conducted.

## Measurements

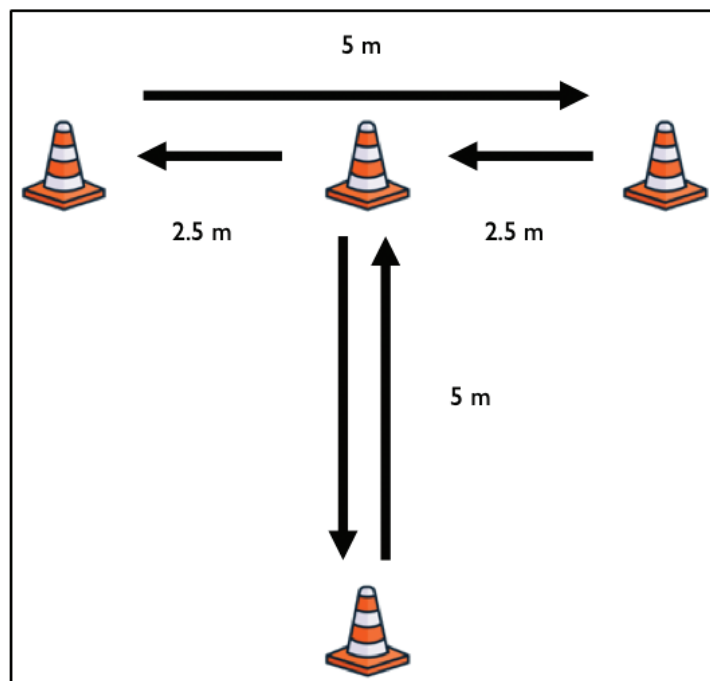
HR was continuously monitored using the Polar Team Pro system (Kempele, Finland). Baseline HR was recorded prior to the warm-up following a 5-min seated rest period. Subsequent measurements were obtained immediately after the warm-up (post-WU) and after the re-warm-up protocol (post-RWU). BT was measured via an infrared ear thermometer (TotiFar CT-30DX, OST, Hsinchu, Taiwan) (Galazoulas et al., 2012). Measurements were taken at three time points: pre-WU, post-WU, and post-RWU.

CMJ was used to assess vertical jump height and explosive leg power. Participants performed three maximal jumps (30 s rest between jumps) with hands on hips to eliminate arm swing contribution (Fashioni et al., 2020). Jump height was recorded using the Optojump™ system (Microgate, Bolzano, Italy) and the best performance was retained for analysis. To evaluate multidirectional performance, the MAT was employed (Koutsouridis et al., 2024), using the Witty photocell timing system (Microgate, Bolzano, Italy) with 0.001 s precision (Figure 2). Photocells were mounted on tripods and positioned at hip height to ensure accurate signal detection and to avoid interference from limb movements. The timing

gates were placed 3 m apart, facing each other, with a defined starting line between them. Participants initiated the test from a starting position, with the lead foot placed 50 cm behind the starting line to minimize the influence of reaction time. The full test procedure is shown in Figure 2. Each athlete complet-

ed a single trial to preserve the acute effect of each condition.

Finally, RPE and PRR were assessed post-protocol using the 10-point Borg scale (Borg, 1982) and the 5-point Karu scale (Karu et al., 2000), respectively.



**Figure 2.** Modified Agility T-test

### Statistical analysis

All statistical procedures were carried out using SPSS software (version 29.0, Tokyo, Japan). Descriptive data are reported as means  $\pm$  standard deviations (SD). Prior to analysis, the assumptions underpinning the general linear model (GLM) were assessed to ensure model validity. A two-way repeated measures ANOVA ( $2 \times 2$ ; Time  $\times$  Protocol) was employed to examine differences across time points and experimental conditions. Where significant main effects or interactions were identified, Bonferroni-adjusted post-hoc tests were applied to explore pairwise comparisons. Statistical significance was defined as  $p < 0.05$ . Effect sizes for main effects and interactions were expressed using partial eta squared ( $\eta^2$ ), interpreted as small (0.01-0.059), moderate (0.06-0.137), and large ( $>0.138$ ) (Richardson, 2011). Additionally, Cohen's  $d$  values, along with 95% confidence intervals, were calculated to quantify effect sizes, categorized as trivial ( $\leq 0.19$ ), small (0.2-0.6), moderate (0.6-1.2), large (1.2-2.0), and very large ( $>2.0$ ) (Hop-kins et al., 2009).

## Results

To assess the impact of the protocols, the study analyzed differences within each group (post-WU vs. post-RWU) and

between groups for the post-RWU measurements. A detailed summary of the results - including means, standard deviations, percentage differences (PD),  $p$ -values, and Cohen's  $d$  effect sizes - is provided in Table 2. The following text focuses exclusively on the effect sizes, as the full statistical data are presented in the table.

The results of the two-way repeated measures ANOVA revealed significant interaction effects between Time and Protocol for RPE ( $F=12.015$ ,  $p=0.005$ ,  $\eta^2=0.500$ ), PRR ( $F=13.032$ ,  $p=0.004$ ,  $\eta^2=0.521$ ), and HR ( $F=16.640$ ,  $p=0.002$ ,  $\eta^2=0.581$ ), indicating that each RWU method influenced these outcomes in a distinct manner.

Regarding main effects, significant effects of Time were observed for PRR ( $F=12.708$ ,  $p=0.004$ ,  $\eta^2=0.514$ ), HR ( $F=26.447$ ,  $p < 0.001$ ,  $\eta^2=0.688$ ), BT ( $F=17.677$ ,  $p=0.001$ ,  $\eta^2=0.596$ ), CMJ ( $F=43.097$ ,  $p < 0.001$ ,  $\eta^2=0.782$ ), and MAT ( $F=10.131$ ,  $p=0.008$ ,  $\eta^2=0.458$ ), with differences between post-WU and post-RWU measurements. Significant effects of Protocol were also found for HR ( $F=63.847$ ,  $p < 0.001$ ,  $\eta^2=0.842$ ) and MAT ( $F=6.484$ ,  $p=0.026$ ,  $\eta^2=0.351$ ), indicating differences depending on the type of RWU applied.

**Table 2.** Statistical results

Variable	Group	Post-WU	Post-RWU	Mean Diff.	PD	p	Cohen's d
CMJ (cm)	Control	36.82±2.13	34.94±1.98	-1.88	-5.11%	<0.001*	1.723
	RWUint	37.47±3.12	36.08±2.47	-1.40	-3.72%	0.005*	0.961
	Comparison between postRWU measurements:				-1.14	-3.23%	0.154
MAT (s)	Control	6.25±0.40	6.44±0.29	0.20	3.04%	0.03*	0.680
	RWUint	6.13±0.43	6.22±0.43	0.08	1.41%	0.56	0.586
	Comparison between postRWU measurements:				0.23	3.42%	0.006*
HR (bpm)	Control	130.23±16.40	98.31±12.05	-31.92	-23.51%	<0.001*	2.310
	RWUint	136.77±20.29	130.92±12.14	-5.85	-4.28%	0.327	0.283
	Comparison between postRWU measurements:				-32.62	-33.17%	<0.001*
Body Temp. (°C)	Control	37.02±0.67	36.47±0.40	-0.55	-1.49%	<0.001*	1.398
	RWUint	36.92±0.40	36.6±0.86	-0.32	-0.88%	0.166	0.409
	Comparison between postRWU measurements:				-0.13	-0.36%	0.492
Perceived Exertion	Control	2.23±0.95	1.19±0.78	-1.04	-46.57%	0.003*	1.029
	RWUint	2.5±1.11	3.0±1.60	0.50	20.00%	0.150	0.426
	Comparison between postRWU measurements:				-1.81	-151.68%	0.004*
Perceived Readiness	Control	4.12±0.79	3.29±0.85	-0.83	-20,10%	<0.001*	1.230
	RWUint	3.96±0.49	3.81±0.64	-0.15	-3.89%	0.303	0.298
	Comparison between postRWU measurements:				-0.52	-15.78%	0.005*

Note. WU–warm up; RWU–re-warm up; PD–percentage difference; CMJ–counter movement jump; MAT–modified agility T-test; HR–heart rate.

## Discussion

The key findings revealed that performance decrements were smaller under the RWUint protocol compared to the CON condition, indicating that the RWU protocol better facilitated athletes' readiness for optimal performance. In CMJ, the decrease in performance was smaller for RWUint (-1.40 cm) compared to CON (-1.88 cm), with RWUint showing a slight improvement. In MAT, the CON group showed a significant increase in time (+0.20 s), while RWUint showed a minor, non-significant change (+0.08 s). BT showed a significant reduction in the CON group (-0.55°C), while RWUint showed no significant change (-0.32°C). HR showed a significant reduction in the CON group (-31.92 bpm) compared to RWUint (-5.85 bpm). As for the subjective measures, RPE decreased substantially in the CON group (-1.04 units), while RWUint showed a non-significant increase (+0.50 units), and PRR was significantly reduced in the CON group (-0.83 units), while RWUint showed a minor, non-significant decrease (-0.15 units).

The present study was designed as a continuation of pre-

vious research aiming to determine the effectiveness of different RWU protocols using a cycle ergometer for basketball substitute players. Earlier studies investigated a 3-min moderate-intensity RWU at 40% of  $VO_{2max}$  (Koutsouridis et al., 2024) and a 1-min high-intensity RWU at 80% of  $VO_{2max}$  (Koutsouridis et al., 2025). This study seeks to build on those findings by further optimizing RWU strategies that are both time-efficient and compliant with FIBA regulations (FIBA, 2024). The current results are interpreted in relation to these earlier protocols, as well as in comparison with a recent study that assessed RWU interventions in non-starter basketball players (Flórez-Gil et al., 2025), thereby contributing to a broader understanding of evidence-based strategies for maintaining performance during competition. Moreover, comparisons with halftime protocols are not methodologically appropriate, as coaches are not constrained by FIBA regulations during halftime and may freely apply any protocol. Hence, such comparisons are minimized.

In the present study, CMJ performance declined by 1.88 cm (-5.11%) after passive rest, compared to a smaller drop

of 1.39 cm (-3.72%) following RWU<sub>int</sub>. Although the between-group difference (post-RWU measurements) did not reach statistical significance, the control condition showed a very large effect size ( $d=1.723$ ), while the RWU<sub>int</sub> yielded a moderate effect ( $d=0.961$ ), suggesting better neuromuscular function maintenance with the intervention. Compared to the RWU40 (Koutsouridis et al., 2024), which resulted in a smaller CMJ decline (-1.72%), and the RWU80 (Koutsouridis et al., 2025), which showed a larger reduction (-4.32%), the current findings fall between the two. In contrast, Flórez-Gil et al. (2025) reported that a plyometric RWU preserved CMJ performance entirely, suggesting that dynamic, task-specific activities may be more effective in mitigating jump-related performance losses during inactivity.

MAT performance worsened by 0.20 s (3.04%) in the CON condition, while the RWU<sub>int</sub> group showed only a 0.08 s (1.41%) change. Although only the CON group exhibited a significant within-condition difference, the between-group comparison post-RWU was significant ( $p=0.006$ ) with a large effect size ( $d=0.917$ ), supporting the protocol's efficacy in preserving agility. Regarding agility, as measured by MAT or similar change-of-direction (COD) tests, the decline observed in the present study is lower than that reported following RWU80 (Koutsouridis et al., 2025) but higher than that observed after RWU40 (Koutsouridis et al., 2024). Therefore, among the three RWU protocols examined for MAT, the RWU40 demonstrated the most favorable outcome. Remarkably, COD performance was preserved under both plyometric and dynamic stretching protocols (Flórez-Gil et al., 2025), with only the control group showing significant loss. The dynamic protocols in that study produced results comparable to those recorded immediately after the initial warm-up, indicating no deterioration. This supports the utility of dynamic RWU formats for sustaining agility-based performance and suggests that RWU protocols featuring exercises that closely resemble basketball movements may be more effective, even if they do not fully comply with FIBA regulations (FIBA, 2024).

HR decreased substantially by 31.92 bpm (-23.51%) in the CON condition, whereas it dropped only 5.85 bpm (-4.28%) following RWU<sub>int</sub>. The large and significant between-protocol difference (-32.62 bpm, -33.17%,  $p<0.001$ ,  $d=1.936$ ) highlights the protocol's role in sustaining cardiovascular activation post-WU. The HR response was more moderate in the present study than that reported following the RWU80, where HR increased post-RWU (5.33%) (Koutsouridis et al., 2025). A larger HR decline than the one observed following RWU<sub>int</sub> was reported after the RWU40 (-9.12) (Koutsouridis et al., 2024). Therefore, the available data support the role of RWU in maintaining cardiovascular readiness.

BT fell by 0.55°C (-1.49%) after passive rest, in contrast to a smaller 0.32°C (-0.88%) reduction after RWU<sub>int</sub>. While the difference between protocols was not significant, the effect size was large in the CON ( $d=1.398$ ) and small in the RWU<sub>int</sub> group ( $d=0.409$ ), showing greater temperature stability with the active protocol. The present findings indicate slightly better thermal preservation than after the RWU80 (-1%) (Koutsouridis et al., 2025), though not as strong as the RWU40 (-0.33%) (Koutsouridis et al., 2024). Notably, the protocol

with longer duration (RWU40) was more effective in maintaining body temperature, which appears to be linked to improved outcomes in both CMJ and MAT performance. This underscores the potential benefit of prolonged RWU activity in preserving physiological readiness and mitigating performance declines during extended bench time.

RPE significantly decreased in the CON by 1.04 points (-46.57%), whereas it increased by 0.5 points (20.00%) in RWU<sub>int</sub>. The difference between post-RWU measurements was substantial (-1.81 points, -151.68%,  $p=0.004$ ,  $d=0.975$ ), reflecting the greater physiological demand associated with the RWU effort. RPE also increased following RWU in prior studies (Koutsouridis et al., 2024; Koutsouridis et al., 2025). The increase observed in the present study was not found after the RWU40 (Koutsouridis et al., 2024), where RPE remained unchanged (0% change), but it was lower than the significant increase seen following RWU80 (25.86%) (Koutsouridis et al., 2025). The elevated RPE values observed following both RWU80 and RWU<sub>int</sub> may indicate that the higher intensity of these protocols induced fatigue, which could have negatively affected performance. In post-activation performance enhancement (PAPE) protocols, fatigue can offset the potentiation benefits of a dynamic stimulus, and performance improvements typically emerge only once fatigue subsides (Blazevich & Babault, 2019). Given that RWU40 led to greater performance outcomes compared to both RWU80 and RWU<sub>int</sub>, it is reasonable that the latter protocols caused a mild but limiting fatigue response - reflected also in the subjective measures reported.

PRR dropped by 0.83 points (-20.10%) in the CON group, but only 0.15 points (-3.89%) after RWU<sub>int</sub>. The between-group post-RWU difference (-0.52 points, -15.78%,  $p=0.005$ ,  $d=0.937$ ) suggests that the RWU<sub>int</sub> protocol better preserved athletes' subjective readiness to perform. PRR was better preserved in the current protocol than after the RWU80 (Koutsouridis et al., 2025), where a more noticeable decline was observed (-6.45%), further supporting not only the above conclusions regarding RPE but also the improved performance results compared to RWU80.

### Limitations and future suggestions

A limitation of the study is the small sample size. Although the minimum required was calculated using G\*Power, a larger sample would enhance the generalizability of the findings. Another limitation is that blood lactate concentration was not measured, which could have provided valuable insights into both athlete fatigue and the elevated RPE and PRR. In a similar protocol conducted during halftime (Yamashita & Umemura, 2022) - three intervals of 3 seconds of maximal-effort cycling and 27 seconds of rest (HII) - it was suggested that the small reduction in muscle pH may increase O<sub>2</sub> availability, and a lactate concentration range of 3-5 mmol·L<sup>-1</sup> was associated with improved performance due to increased muscle excitability. Future studies may consider including measurements of blood lactate concentration, as well as exploring protocols of varying duration and intensity applied across different age groups, competitive levels, and in female athletes.

## Practical applications

The study's findings have significant applications to basketball, a sport that requires a lot of muscular strength and power. There is little data to support the structured use of cycle ergometers in RWU, despite the fact that many teams use them behind benches. This study demonstrates how RWU protocols work to maintain physical readiness during prolonged bench time, and eliminate the requirement for a transitional period prior to returning to play. RWUs should be intense enough to maintain body temperature and activate the neuromuscular system without causing further fatigue for optimal results.

Specifically, even though the RWUint outperformed passive rest, it was probably not the best protocol when compared to others reported in the literature, like RWU40 (Koutsouridis et al., 2024). However, shorter high-intensity protocols like RWUint might provide a useful balance between feasibility and efficacy because of time constraints during games. In order to encourage regular use and improved integration into team preparation, coaches should also teach players the importance of RWU routines.

## Conclusions

The results of the current study show that non-starter basketball players tend to lose the benefits of the initial WU when sitting on the bench, which may result in reduced readiness for optimal performance when they enter the game. This is especially important given the sport's demands for high-intensity and power-related actions. The results further highlight the importance of implementing an active RWU protocol to mitigate such declines in performance. Across all measure variables - performance measures, physiological measures and subjective ratings - subjects who completed an interval cycling RWU showed improved outcomes compared to those who passively rest. Nevertheless, compared with previous research, other cycling-based RWU protocols, particularly those performed at lower and steady intensities, were more effective in attenuating performance decrements and allowed athletes to return to play closer to their optimal performance levels.

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### Conflict of interest

The authors report there are no competing interests to declare.

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