

นิพนธ์ต้นฉบับ (Original article)

วิทยาศาสตร์การโค้ช (Sports Coaching Science)

## ACUTE EFFECT OF DIFFERENT FIVE-MINUTE WARM-UP PROTOCOLS ON FLEXIBILITY AND SPRINT ABILITY IN COLLEGIATE SOCCER PLAYERS

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### ABSTRACT

Insufficient warm-up (WU) of substitute soccer players could limit the performance and increase risk of injury. Different WU protocols were designed to help them get an effective WU in a shorter time frame for enhancing their performances. The aim of this study is to find a five-minute WU protocol that can improve flexibility and Repeated Sprint Ability (RSA) with an acceptable fatigue, as compared to no warm up condition. Twelve healthy collegiate male soccer players participated in this study. Subjects performed 4 randomly different warm up protocols on four nonconsecutive days: (a) no warm up (NW); rest of 5 minutes, (b) dynamic warm up (DW); jogging of 2:30 minutes and 2:30-minute of dynamic warm up, (c) dynamic resistance warm up (DRW); DW plus 8 repetitions of body weight squats, and (d) dynamic sprint warm up (DSW); DW plus two 20-m shuttle sprint. Hamstring flexibility, RSA parameters and Borg's RPE scale were measure. Flexibility was significantly improved after performing DRW and DSW, but not significant different in NW and DW, ( $p < 0.01$ ). DSW and DRW protocols significantly improved RSA parameters compared with NW as observed in average time and total time. The fastest time was improved only in DSW protocol ( $p < 0.05$ ). Fatigue for DW, DSW and DRW was not different from NW. Improved flexibility and RSA performance in DSW and DRW would be suggested for substitute soccer players with limited WU time.

**Keywords:** Short-duration warm up / Substitute soccer player / Body weight squats / Hamstring flexibility / RPE scale

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**ผลระยะสั้นของรูปแบบการอบอุ่นร่างกายในระยะเวลา 5 นาที ในความอ่อนตัวและความสามารถในการวิ่งด้วยความเร็วของนักกีฬาฟุตบอลชายระดับมหาวิทยาลัย**สุชีรา ชื่นสงวน<sup>1</sup>, คัคณานต์ สรุงบุญมี<sup>2</sup>, อมรพันธ์ อัจจิมาพร<sup>1</sup> และ กรกฎ พานิช<sup>1</sup><sup>1</sup>วิทยาลัยวิทยาศาสตร์และเทคโนโลยีการกีฬา มหาวิทยาลัยมหิดล นครปฐม ประเทศไทย 73170<sup>2</sup>ศูนย์เหมืองข้อมูลและชีวการแพทย์สารสนเทศ คณะเทคนิคการแพทย์ มหาวิทยาลัยมหิดล นครปฐม ประเทศไทย 73170**บทคัดย่อ**

การอบอุ่นร่างกายที่ไม่เพียงพอของผู้เล่นฟุตบอลตัวสำรองอาจเกิดข้อจำกัดทางศักยภาพของร่างกายและเพิ่มความเสี่ยงต่อการบาดเจ็บ รูปแบบการอบอุ่นร่างกายที่แตกต่างกันถูกออกแบบมาเพื่อช่วยให้ผู้เล่นตัวสำรองได้รับการอบอุ่นร่างกายที่มีประสิทธิภาพในช่วงเวลาที่สั้นลงและยังคงช่วยเพิ่มศักยภาพด้วย วัตถุประสงค์ คือ ค้นหารูปแบบการออกกำลังกายที่ใช้ระยะเวลาประมาณ 5 นาที ที่สามารถเพิ่มความยืดหยุ่น (sit and reach test) และ ความสามารถในการวิ่งด้วยความเร็วช้าๆ (6 รอบ รอบละ 20 เมตร) โดยมีความล้า (Borg's scale) พอประมาณ โคนเปรียบเทียบกับการที่ไม่ได้รับการอบอุ่นร่างกาย การศึกษานี้ทดสอบในนักกีฬาฟุตบอลชาย 12 คน โดยที่ทดสอบรูปแบบการอบอุ่นร่างกายที่แตกต่างกัน 4 แบบ ซึ่งจะทำการสุ่มและปฏิบัติใน 4 วันที่ไม่ต่อเนื่องกัน ได้แก่ (1) no warm-up (NW); นั่งพักเฉยๆ 5 นาที (2) dynamic warm-up (DW); วิ่งเหยาะๆ 2:30 นาที และ อบอุ่นร่างกายแบบไดนามิก 2:30 นาที (3) dynamic resistance warm-up (DRW); DW ต่อด้วยการทำท่าสควอท(น้ำหนักตัว) 8 ครั้ง (4) dynamic sprint warm-up (DSW); DW ต่อด้วยการวิ่งด้วยความเร็วไปและกลับ 20 เมตร ซึ่งทำการวัดความอ่อนตัวของการเนื้อแฮมสตริง (Hamstring flexibility) ความสามารถในการวิ่งด้วยความเร็วช้าๆ (RSA parameters) และ ความรู้สึกล้าของขา (Borg's RPE scale) ผลจากการวิเคราะห์ข้อมูลบ่งชี้ว่าความอ่อนตัวดีขึ้นหลังจากปฏิบัติรูปแบบการอบอุ่นร่างกายแบบ DRW และ DSW ( $p < 0.01$ ) แต่ไม่พบความแตกต่างในการอบอุ่นร่างกายแบบ NW และ DW เมื่อเทียบกับก่อนอบอุ่นร่างกาย นอกจากนี้ DSW และ DRW ยังเพิ่มความสามารถในการวิ่งด้วยความเร็วช้าๆเมื่อเทียบกับ NW ซึ่งพบในเวลาเฉลี่ย (AverT) และเวลาทั้งหมด (TotalT) ส่วนเวลาที่เร็วที่สุด (FastT) นั้น พบว่า ดีขึ้นใน DSW เท่านั้น ( $p < 0.05$ ) ความล้าที่เกิดขึ้นหลังจากการอบอุ่นร่างกายทั้ง 3 แบบไม่แตกต่างจาก NW ดังนั้นจึงแนะนำการอบอุ่นร่างกายแบบ DRW และ DSW สำหรับนักกีฬาฟุตบอลตัวสำรองที่มีเวลาในการอบอุ่นร่างกายที่จำกัดซึ่งใช้เวลาเพียงประมาณ 5 นาที

**คำสำคัญ:** การอบอุ่นร่างกายระยะสั้น / นักกีฬาฟุตบอลตัวสำรอง / สควอทด้วยน้ำหนักตัว / ความยืดหยุ่นของกล้ามเนื้อแฮมสตริง / อัตราการรับรู้ถึงความเหนื่อยล้า

## INTRODUCTION

A warm-up (WU) before a practice or a match competition provides different physiological advantages. The importance of an effective warm up for a soccer player requires the movements be similar to, or specifically associate with the game. Increase flexibility, range of motion and blood flow, including elevating body temperature are the desired effect of WU and widely accepted as important factors that can improve performances<sup>1</sup> and prevent injuries.<sup>2</sup>

Warm up (WU) protocols can be completed in different time frame, in which the short duration WU have shown to improve performances. Several studies have reported that short duration dynamic warm-up of moderate intensity is likely to significantly improve short term performance in either healthy subject or athlete. Ten minutes of dynamic warm up activities (consist of ten different dynamic stretching exercises and five different movement drills) could decrease the shuttle run time, increase the medicine-ball throw distance and five steps jump distance<sup>3</sup>. A dynamic stretching of 7 minutes has shown an increase in vertical jump height and electromyography (EMG) activity<sup>4</sup>. Yapicioglu B. et al.<sup>5</sup> found an increase in vertical jump height following 3 minutes of jogging plus nine different dynamic stretching exercises in fifteen colligate athletes. Even in the limited time frame, 3–5 minute warm up of moderate intensity is likely to be significantly improved short-term performance in a range of tasks, but not specific for soccer.<sup>6</sup> To our knowledge, no short-duration WU protocols have been specifically designed for soccer.

Substitute soccer players can be unexpectedly called to the game with insufficient or even lack of WU, causing disadvantages for both the players and team. Five-minute time frame should be long enough for the substitute players to get WU. It is therefore the purpose of this study to investigate the effect of short-duration, approximately 5-minute, WU protocols on the substitute soccer players, by testing the improvement in flexibility and RSA performance which are commonly demanded for a soccer game.

## METHODS

TABLE 1: Subject Information (mean  $\pm$  SD)

VO <sub>2max</sub> (ml/kg/min) <sup>7</sup>	63.02	$\pm$ 14.36
Age (yrs)	20	$\pm$ 1
Body Weight (kg)	64.68	$\pm$ 6.92
Height (cm)	172.42	$\pm$ 7.32
BMI (kg/m <sup>2</sup> )	21.7	$\pm$ 1.7
Body Fat (%)	15.73	$\pm$ 1.94
RHR (bpm)	68.50	$\pm$ 6.08

**Participants:** Twelve male soccer players (Table 1) from a collegiate soccer team volunteered to participate in this study. All subjects were healthy with  $VO_{2max}$  more than 45 ml/kg/min<sup>8</sup> and had no musculoskeletal injury, acute impairment of the spine or lower extremities, vestibular dysfunction, or balance disorder. All subjects signed informed consent prior to participation. The protocol was approved by the Human Research Ethics Committee of Mahidol University, Salaya campus, Nakornpathom, Thailand.

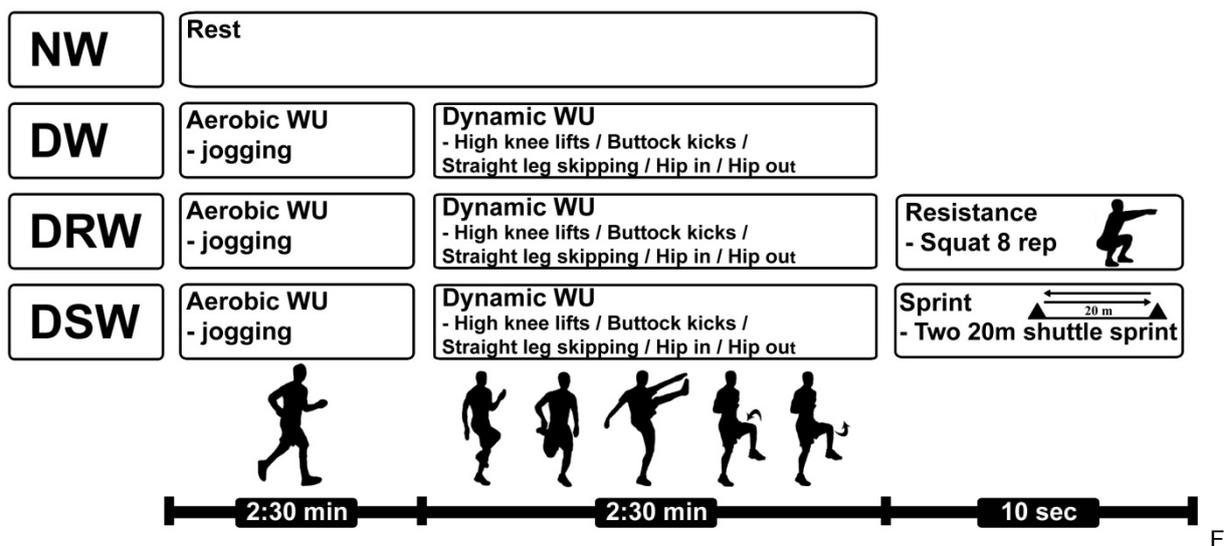


FIGURE 1: WU protocol

**Warm-up Protocols:** Three WU protocols were studied and individually compared with the NW protocol in which the subject simply rested in the sit position for 5 minutes. (Figure 1) The designed WU protocols consisted of 2:30 minute aerobic and 2:30 minute dynamic stretching phases. The aerobic phase was the moderate-intensity jogging (55% to 69% of maximum heart rate; ACSM's Advanced Exercise Physiology,<sup>9</sup> which was monitored and adjusted for each subject using the heart rate monitor (Polar FT1, Finland). The dynamic stretching included the following sequential stretching movements: high knee lifts, buttock kicks, straight leg skipping<sup>10</sup>, hip in and hip out<sup>11</sup>, 30 seconds for each stretch. Two twenty-meter (20-m) shuttle sprint and 8 body-weight squats<sup>12</sup> were added after DW to make DSW and DRW protocols respectively. The two 20-m shuttle sprints was performed at 100% of the subjects' perceived maximum effort.<sup>13</sup> (Table 2)

TABLE 2 WU Protocol

	Execution	Duration
Rest	- Rest on sit position	5 minutes
Aerobic WU	- Moderate-intensity jogging (55% to 69% of maximum heart rate)	2:30 minutes
High knee lifts	- Stand with the feet width slightly apart. Lift your knee high while bringing your heel toward your gluteus and keeping your toes up. Drive your leg back toward the ground and repeat the movement on the other side.	30 seconds
Buttock kicks	- Stand with the knees close together, arms either down by the side of behind on top of the bottom. Flex the knee behind you so it touches the glute, return that leg to the floor and repeat the movement on the other side.	30 seconds
Straight leg skipping	- Stand with the feet width slightly apart. Raise the leg forward, while swinging the same arm backward and opposite arm forward. Lower the leg down swing the arms. Repeat the movement on the other side.	30 seconds
Hip in	- Stand with the feet width slightly apart. Lift your knee to the side of trunk and rotate your hip inwards. Repeat the movement on the other side.	30 seconds
Hip out	- Stand with the feet slightly apart. Lift your knee to center of trunk and rotate your hip outwards. Repeat the movement on the other side.	30 seconds
Resistance	- Body weight squat: Stand with the feet shoulder-width apart. Slowly bend at the knees and drop hips to lower body apart with all weight on the heels. At the end of the exercise, strongly push back up to the starting position.	10 seconds
Sprint	- Two 20-m shuttle sprints: Straight-line sprints from starting line with 100% of the subjects' perceived maximum effort and sprint back to the starting line.	10 seconds

**Design:** Participants were instructed to perform 4 different warm-up protocols (Figure 1), no warm-up (NW), dynamic warm-up (DW), dynamic sprint warm-up (DSW) and dynamic resistance warm-up (DRW), on 4 nonconsecutive days within 4 weeks in a randomized design at a soccer field. Each test day was conducted more than 48 hours after a match or hard physical training and before daily training activity, to minimize fatigue from the previous exercise. On the experimental day, participants performed the sit-and-reach test before doing each WU protocol. After doing a WU protocol, an active rest of 30 seconds was performed before doing another sit-and-reach test, RSA and assessment of leg fatigue perception (RPE). For NW protocol in which participants were required to sit for 5 minutes, the tests were done immediately after the protocol without 30-second active rest. (Figure 2)

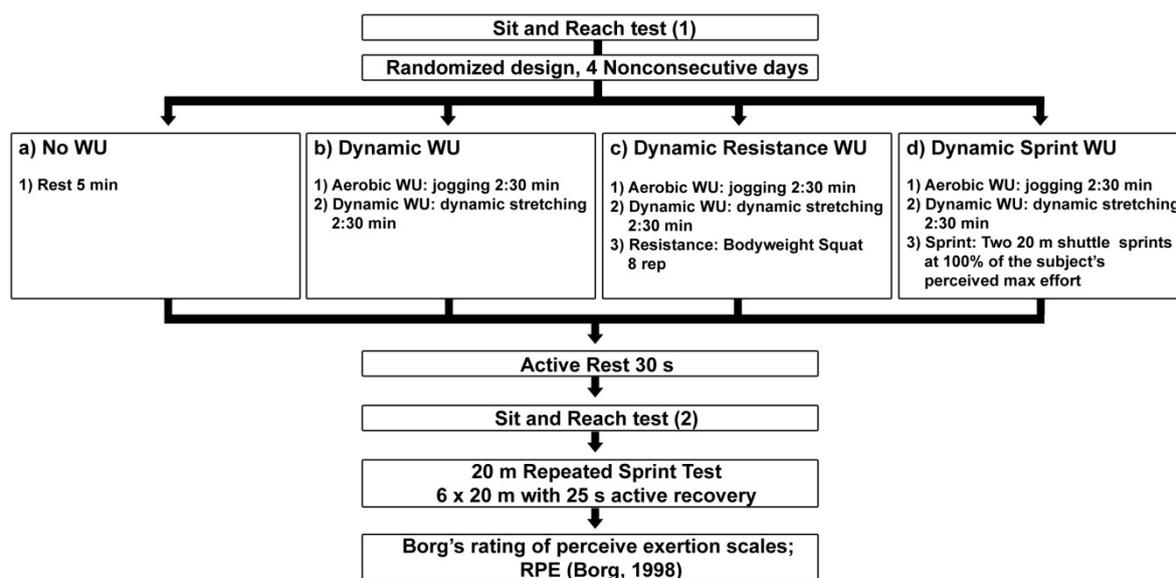


FIGURE 2: Experimental design

**Sit-and-Reach Test:** This flexibility measurement was conducted twice, using the standard test equipment, and the best result was used in the analysis.<sup>14</sup> This test was performed before and after all the WU protocols. (Figure 2)

**20-meter repeated sprint test (repeated-sprint ability: RSA):** This test is broadly described as the ability to perform repeated short (~3–4 second, 20–30 meter) sprints with only brief (~10–30 second) active recovery between bouts<sup>15</sup>, consisting of six straight-line sprints (6 x 20 m with 25 s active recovery). During the active recovery, participants slowly jogged back to the starting line and wait for the next sprint. Sprint time was measured by a custom-made infra-red timing system located at the starting line and the finishing line (1- meter high). The active recovery time was controlled by a hand-held stopwatch. The fastest time (FastT) and average time (AverT) among sprints, total time (TotalT), and percentage decrement score (%Decre)<sup>16</sup> were evaluated from RSA. The %Decre is the most valid and reliable method of quantifying fatigue in RSA tests,<sup>16</sup> and can be calculated using the formula from Fitzsimons et al.<sup>17</sup>

**Borg's rating of perceive exertion scales; RPE:** To assess the perception of leg fatigue, Borg's rating of perceive exertion scales<sup>18</sup> was used.<sup>19</sup> This test was performed immediately after 20-meter repeated sprint test.

### Statistical analysis

A paired t-test was used to test the difference of flexibility before and after each WU protocol and also used to test the difference of RSA performance parameters of each designed WU protocol as compared to no warm-up (NW) condition (SPSS version 18.0). The level of significance was assigned at  $p < 0.05$ .

## RESULTS

### Flexibility

The two means from sit and reach test performance (before vs. after) of NW, DW, DSW and DRW for all subjects (N=12) were  $12.33 \pm 7.40$  vs.  $13.42 \pm 5.62$ ,  $14.75 \pm 4.45$  vs.  $16.33 \pm 3.96$ ,  $10.67 \pm 6.98$  vs.  $14.67 \pm 5.79$  and  $12.00 \pm 5.56$  vs.  $14.25 \pm 5.22$ , respectively (Figure 3). Flexibility, as observed from the sit-and-reach test, was significantly improved in DSW ( $t_{11} = -3.14$ ,  $p = 0.009$ ) and DRW protocols ( $t_{11} = -3.23$ ,  $p = 0.008$ ), but not in DW protocol ( $t_{11} = -2.19$ ,  $p = 0.051$ ).

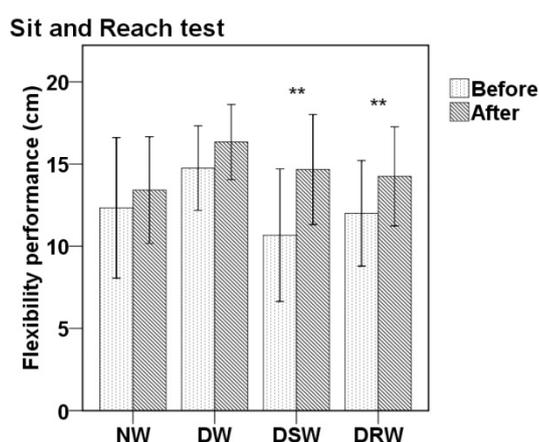


FIGURE 3: Sit and reach test before and after performing each WU protocol. (\*\* $p < 0.01$ )

### Repeated Sprint Ability

The mean fastest time (FastT) for all subjects in NW, DW, DSW and DRW protocols were  $3.22 \pm 0.23$ ,  $3.25 \pm 0.21$ ,  $3.12 \pm 0.19$  and  $3.15 \pm 0.21$  sec, respectively. FastT of DSW was significantly lower than NW ( $t_{11} = 2.47$ ,  $p = 0.031$ ) but not different in DW ( $t_{11} = -0.36$ ,  $p = 0.724$ ) and DRW ( $t_{11} = 1.51$ ,  $p = 0.159$ ) when compared to NW. Average time (AverT) for each WU was  $3.40 \pm 0.20$ ,  $3.40 \pm 0.22$ ,  $3.29 \pm 0.20$  and  $3.29 \pm 0.22$  sec, respectively. AverT of DSW and DRW were significantly lower than NW (DSW:  $t_{11} = 2.72$ ,  $p = 0.020$ , DRW:  $t_{11} = 2.21$ ,  $p = 0.049$ ). AverT for DW was not significantly different from NW ( $t_{11} = -0.01$ ,  $p = 0.992$ ). The mean total time (TotalT) for each protocol was  $20.43 \pm 1.21$ ,  $20.43 \pm 1.32$ ,  $19.71 \pm 1.19$  and  $19.73 \pm 1.31$  sec, respectively. TotalT of DSW and DRW were lower than NW (DSW:  $t_{11} = 2.72$ ,  $p = 0.020$ ; DRW:  $t_{11} = 2.21$ ,  $p = 0.049$ ) but not different for DW compared to NW ( $t_{11} = -0.01$ ,  $p = 0.992$ ).

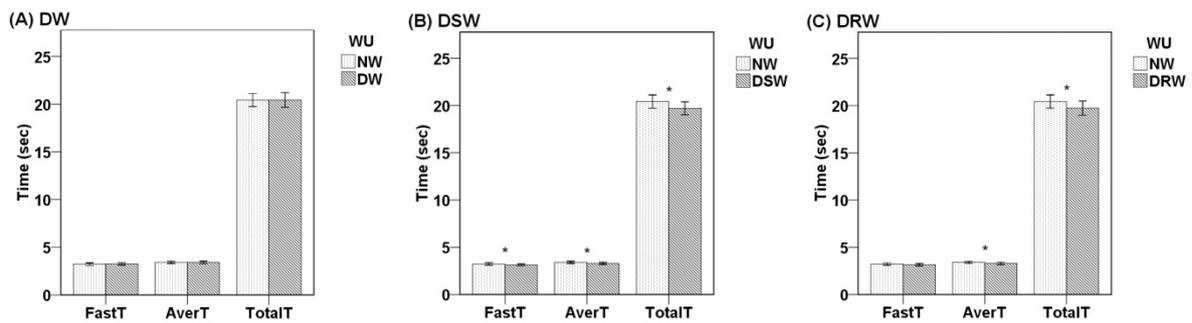


FIGURE 4: Repeated Sprint Ability (RSA) parameters (FastT = fastest time; AverT = average time; TotalT = Total Time) for (A)DW = dynamic warm-up (B) DSW = dynamic warm-up plus sprint and (C) DSW = dynamic warm-up plus resistance compared with no warm-up (NW) for all subjects. (\* $p < 0.05$ )

## Fatigue

Fatigue scores were evaluated from Borg's scale and %Decre. Perceived leg fatigue from the mean Borg's scale for all subjects in NW, DW, DSW and DRW protocols were  $5.08 \pm 2.19$ ,  $4.75 \pm 2.01$ ,  $4.92 \pm 2.23$  and  $4.42 \pm 1.88$ , respectively. %Decre for all subjects in NW, DW, DSW and DRW protocols was  $5.765 \pm 2.66$ ,  $4.81 \pm 1.76$ ,  $5.24 \pm 1.73$  and  $4.38 \pm 1.86$ , respectively. No significant difference from NW protocol was observed for all protocols (Table 3).

TABLE 3: Paired *t*-test Results Fatigue Score of Each WU Protocol in Comparison with NW Protocol

		Mean	Std. Deviation	t	df	P for paired-sample
						t-test
Borg's scale	DW	0.33	1.44	0.80	11	0.438
	DSW	0.17	1.11	0.52	11	0.615
	DRW	0.67	1.50	1.54	11	0.151
%Decre (%)	DW	0.96	2.70	1.24	11	0.243
	DSW	0.53	3.29	0.55	11	0.591
	DRW	1.38	3.32	1.44	11	0.177

## DISCUSSION

The purpose of this study was to design different 5-minute warm-up protocols and study their short-term effect on flexibility and sprint performance, in comparison with the controlled no warm-up (NW) protocol. The design idea was to cover major aspects of warm-up phases, i.e. cardiovascular and stretching components (DW), shorten the time and add few other components as seen in DSW and DRW protocols. Fatigue from these WU protocols was not different from NW protocol. Results indicate that flexibility and average time and total time

of RSA were improved after performing DRW and DSW, but not found DW. The fastest time of RSA was improved only in DSW protocol.

#### *DW and NW*

It is well known that basic components of the most famous warm up protocol consist of cardiovascular and stretching phases, reported to increase performance.<sup>13</sup> Bishop's<sup>6</sup> review the literature indicated the beneficial effects of 3-5 minute DW of moderate intensity could improve vertical jump, speed as well as peak power performances as shown in several studies. Here we designed this two-phase of DW protocol, with a shorter period of time (2:30 minutes of cardiovascular and 2:30 minutes of dynamic stretching components). Dynamic stretching was selected due to several advantages over static stretching, such as more improved hamstring and quadriceps muscles flexibility<sup>20</sup>, in which it is recommended more than static stretching.<sup>21</sup> Dynamic stretching following cardiovascular has shown an increase in flexibility<sup>22</sup> and sprint performance.<sup>23</sup> However, with 5 minutes of the DW protocol, the positive result was not observed from our study (Figure 3A and Figure 4A). The results found in this study could be explained by the fact that eventhough dynamic stretching can improve muscular performance by increasing muscle temperature ( $T_m$ ) and core temperature ( $T_c$ ) through the controlled movement over the active range of motion.<sup>24</sup> However, increased  $T_m$  from cutaneous vasoconstriction at the onset of dynamic exercise, following by cutaneous vasodilation<sup>25</sup> could take the time longer than the time that spent in this study protocol. Thus it appears that DW protocol used in this study was either too low intense and/or insufficient time to improve flexibility and sprint performance in collegiate soccer players.

#### *DSW and NW*

When compared with NW, DSW had shown to improve the flexibility (Figure 3B) and RSA performance (Figure 4B). Twenty-meter sprint specifically added after the DW to make the DSW protocol might further help to increase  $T_m$ . Sprint as a part of the warm up protocol has been reported to improve the test sprint performance because it might serve as the rehearsal just prior to the test<sup>13</sup> or generally help to increase the muscle temperature. Increased  $T_m$  has been shown to reduce muscle stiffness and thus increasing flexibility. The enhanced effect of different exercise performances including sprint has also reported to be associated with increased  $T_m$ .<sup>26</sup> Despite no data of  $T_m$ , a 5-minutes DW plus two 20-m shuttle sprint protocol (DSW) might appear to be sufficient intensity to elicit muscle temperature related benefits and is therefore an effective preparation to improve flexibility and sprint performance for substitute soccer players.

### *DRW and NW*

Compared to NW, DRW had shown to improve both flexibility (Figure 3C) as well as average time and total time of RSA (Figure 4C). The positive result from this DRW warm up protocol could be from increased  $T_m$ .  $T_m$  has been reported to elevate after squats<sup>27</sup> and that could reduce muscle stiffness, increase flexibility and improve RSA performance.

Enhanced performance after DRW could also be from the effect of post-activation potentiation (PAP) due to the added body weight squats in the DRW protocol. Eight body weight squats added after dynamic stretching could induce PAP and further enhance performance. It is generally known that PAP is a phenomenon in the motor neuronal level by which the output muscle force is enhanced due to its previous activation. PAP can be induced from different methods and depends on different factors including appropriate loading.<sup>28</sup> Adding squats with additional load to the warm-up protocol may not be able to improve RSA performance.<sup>12</sup>

### CONCLUSION

We have designed three different 5-minute warm up protocols and studied their short-term effects. Flexibility and sprint performance had been improved after the warm up protocols consisting of jogging and dynamic stretching plus either the sprint (DSW) or squats (DRW). These two protocols are recommended in the situation of limited warm up time as in the case of substitute players or half-time re-warm up.<sup>29</sup> In the limited space, DRW might be preferred to DSW. These 5-minute warm-up might also be interested when prevention of overheating or thermoregulatory strain is needed during the hot weather games.

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