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The Effect of a Field-Based Warm-Up on Performance in BMX Cycling

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Abstract

Performing a warm-up in sport is generally seen as an essential part of any pre-race routine. However, studies have reported mixed findings on the benefits of such routines, and few studies have looked at the influence of warm-up on BMX performance. Therefore, this study aimed to 1) ascertain if a warm-up had an effect on BMX performance 2) whether a rest period post warm-up affected performance, and 3) if a sub-maximal warm-up could influence performance to a greater extent. The study assessed 11 competitive BMX riders in a field-based environment on an indoor BMX track. Riders performed three trials. In trial one, they performed a maximal effort lap on the track without a warm-up. In trial two, riders performed a conventional warm-up, generally consisting of sprint intervals, then sat for 10-minutes in a holding area before performing another timed sprint lap. Lastly, for trial three, rider performed a structed sub-maximal warm-up then performed a final maximal effort sprint on the track. The results found no statistical differences between the trials ($F(2,30)= .18$; $p \geq .05$; $\eta 2=.01$). However, there was a difference in mean times when comparing trial 2 (34.1 ± 3.70 s) and 3 (34.2 ± 3.70 s) to the non-warm up trial (34.9 ± 3.58 s). The time differences may appear marginal, but when applied to race data they could have a potential impact. Research has shown that 0.49 ± 0.36 s faster lap times can result in a rider moving up at least one position or progressing to the next round in the heats.

Keywords

Bicycle Motocross; Warm-Up; Fatigue.

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1 Introduction

Bicycle motocross (BMX) cycling is a cycling discipline in which up to 8 riders start on a hill and race around a man-made track. Races last between 30-45 seconds (Cowell et al., 2012) and therefore the discipline is considered a sprint type event (Lievens et al., 2021). Several studies have identified a strong positive correlation exists between the start of a BMX race and the final position (Gross et al., 2017; Janssen & Cornelissen, 2017; Rylands & Roberts, 2014). There are various elements of the BMX start that could be developed to improve the start, for example rate of force development (RFD), strength, or power (Daneshfar, 2020). As a blanket term in sport, these and other output measures are referred to as performance characteristics (Kittel et al., 2019). Several intervention studies have looked at how these performance characteristics could be developed in a variety of sports (Micke et al., 2018; Støren et al., 2008; Sunde et al., 2010). For an athlete to perform optimally and produce their optimal peak power, RFD, or strength, they must be physically prepared. This was an observation noted by Bishop (2003), who stated that an optimal warm-up can influence physiological and performance characteristics. Bishop (2003) defined a warm-up as the increase of muscle temperature by 2 degrees and identifies two technique classifications that can be used to achieve this: Active and passive warm-up. Active warm-up involves physical movement that results in a muscle temperature increase. Passive warm-up involves a muscle temperature increase through an external means such as hot bath, heat pad or heated clothing.

Several studies have looked at the effect of a warm-up on sprint type events such as swimming, kayaking, 100m track running (Dalamitros et al., 2018; Hogan, 2021; Park et al., 2021). These studies found that a pre-race warm-up had a positive effect on performance. There have been some cycling specific studies conducted. For example, Faulkner et al., (2013) and Sargeant (1987) looked at the effect of warm-up strategies on velodrome track sprinters. One of the key findings noted in both studies were that peak power outputs increased between 2 % and 10 % as the result of an effective warm-up. However, not all authors agree that a warm-up has a positive impact on performance. Some studies have found that warm-up had no impact on performance (Koch et al., 2003; Lindblom, 2012; Ribeiro, 2014). Although these studies found no difference between warm-up and no warm-up trials, they did note that a warm-up should be included as a pre-race routine, as it could aid in injury prevention. For example, Cetta et al., (2023) looked at the impact of a pre-race routine on injury prevention and found 87.5 % of cyclists who did not warm-up experienced injuries, while only 13 % of cyclists who did warm-up experienced injuries.

Studies that have found a positive relationship between warm-up and performance have attempted to ascertain the optimal warm-up strategy for specific types of sports. Tomaras and MacIntosh (2011) looked at the fatigue element of a warm-up when using intensity strategies in a sprint type event. Tomaras and MacIntosh (2011) hypothesised that high intensity warm-ups could reduce the phosphocreatine level in an athlete's muscles and have a negative effect on performance. The authors looked at this supposition and devised two warm-up strategies with varying intensities, then analysed the relationship between them on a 200-meter timed sprint on an indoor track (velodrome). The authors found the warm-up using a combination of steady state and sprints of between 60 % to 95 % (maximal HR) had a fatigue effect on riders' performance, but the same warm-up strategy of lower intensity between 60 % to 70 % (MHR) did not show any effect of fatigue. Other aspects of the warm-up strategy have also been shown to have an impact on warm up such as volume McGowan (2015) and time between warm up and a race (Bishop, 2003; Crowther et al., 2017).

With respect to warm-up in BMX cycling no empirical studies have looked into the relationship between warm-up and performance. Therefore, ascertaining if a warm-up does have an impact on performance would aid coaches in planning pre-race routines.

The aims of the current study were to 1) ascertain if a warm-up had an effect on BMX performance 2) whether a rest period post warm-up affected performance, and 3) if a sub-maximal warm-up could influence performance to a greater extent.

2 Material and Methods

2.1 Participants

Eleven national standard BMX cyclists (2 females, 9 males, mean age 21.5± 6.9 yrs, mean body mass 71 ± 3 kg) participated in the study. All riders had competed at national and/or international level for a minimum of 5 years and had 8 years race experience of riding the track used for testing. Two weeks prior to the testing riders were given an information sheet outlining the test protocols and the aims of the study. Written and informed consent was obtained one week before the study. Ethical approval was granted by the University of Central Lancashire and University of Derby Human Studies Board (HEALTH 0454) and the study was conducted according to the Helsinki agreement.

2.2 Equipment

Riders used their own bicycle and equipment for all three trials. Four timing gates (Fusion Sport, Smart speed Pro) were placed on the track. The first gate was placed at the top of the 5-meter start hill and activated when the riders left the start gate. The second was placed at the bottom of the start hill, the third at the first berm, and the final gate was placed at the finish line.

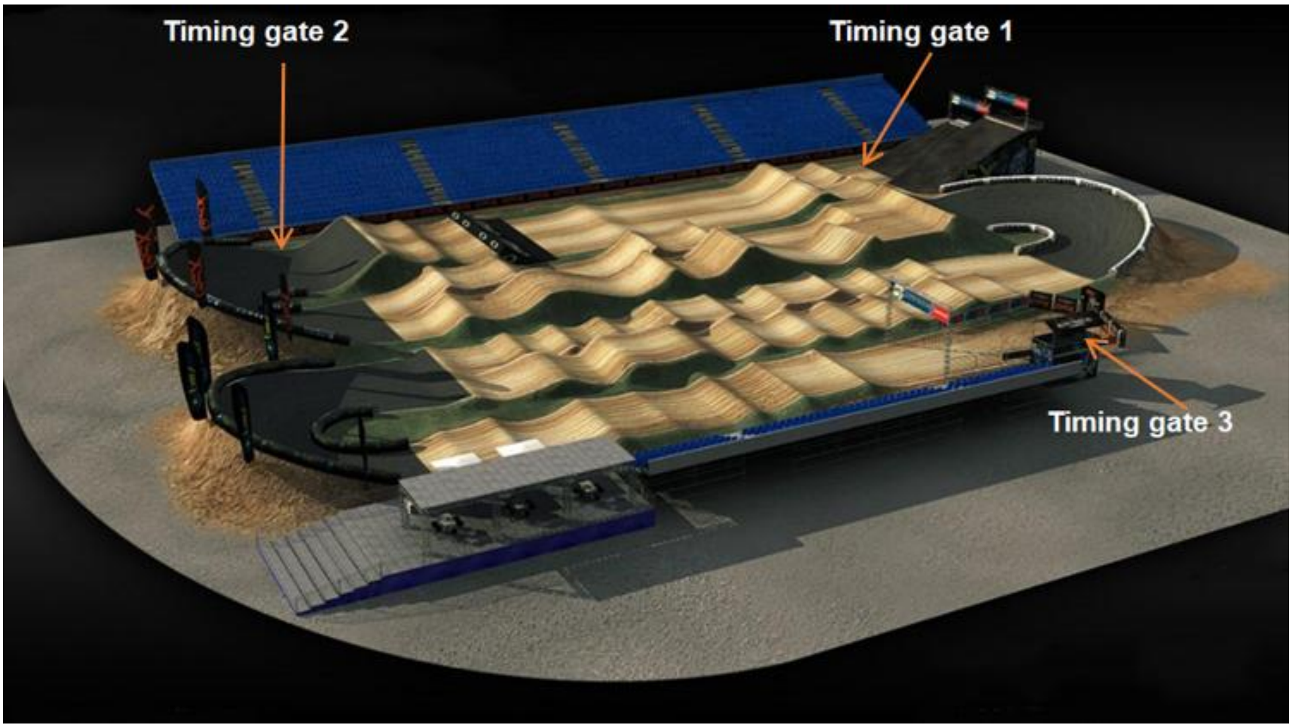

Figure 1. Schematic diagram of the Manchester indoor BMX track showing position of the timing gates.

2.3 Design

Three trials were undertaken during this study to analyse any impact of different warm-up strategies on BMX lap times with 48-72 hours between trials. The trials were field-based and all performed on a purpose-built indoor BMX track at the National Cycling Centre in Manchester (United Kingdom, see figure 1). The riders were in the pre-competition phase of their season and had not trained for a minimum of 48 hours prior to each trial. Each rider ensured they had eaten a minimum of 1 hour before the test and consumed fluids throughout the sessions to ensure they were hydrated. A health questionnaire was completed on the day of testing to ensure the riders had no injuries or medical conditions that may have an impact on the athlete's health or results of the study.

Prior to the trials riders had a 15-minute familiarization session in which they rode from the start gate (Pro-Gate, Rockford, Illinois, USA) situated on the 5-meter start hill. Participants rode around the track at a self-paced submaximal intensity. In trial 1 riders then returned to a holding area and sat for 10-minutes to enable the riders to recover (Faulkner (2013). Post cool down participants were instructed to mount their bicycle at the start gate and perform a maximal effort sprint lap around the whole track. The rider's split times at each timing gate were then recorded in the timing gates handheld computer.

Trial 2 determined the effect of a delay between warm-up and track sprint. In the trial riders performed a 15-minutes warm-up on their bike consisting of maximal sprint intervals and steady submaximal riding. Riders were then taken to the holding area and instructed to sit for 10-minutes. During this period riders were asked not to undertake any form of exercise, as this was intended to mimic a typical race day protocol. After the 10-minutes riders were instructed to return to the start gate and again performed a maximal effort lap of the whole track. Split times were again recorded.

For the final trial (trial three), riders were taken to the holding area and performed 10-minutes of sub-maximal exercise. Riders performed unloaded squats (i.e. non-jumping) at a rhythm of 2 s/ 2 s (eccentric/ concentric) and a further 5 squats at a rhythm of 1 s/ 1 s after a 30 s rest. After 20 s rest, five continuous counter jump movements (CMJs) were performed at ~65 % of the participants' self-perceived maximal effort and, after a further 30 s rest, maximal CMJs were performed every 30 s (typically 4-7 jumps were performed in all trials). The CMJ was performed from a stationary upright standing position with hands positioned on the hips, making a preliminary downward movement with the hips and knees flexed, and immediately jumping vertically up as high possible (Mina et al., 2019). After the 10-minutes riders were instructed to walk to the start gate with their bicycle. Again, each rider performed a sprint lap of the whole track.

2.4 Statistical Analysis

A repeated measure ANOVA was use to ascertain any statistical differences in time between the trials. Effect size of each of the variables was also calculated using Cohens' d effect size ($\eta 2$) and classified as trivial (<0.2), small (>0.2-0.6), moderate (>0.6-1.2) and large (>1.2-2.0) (Batterham & Hopkins, 2006). IBM Statistical Package for the Social Sciences statistical (SPSS) version 24 was used for all statistical analyses (IBM Inc., Chicago, IL) and a p <0.05 was accepted as the level of significance.

3 Results

The result found the main effect for conditions showed no significant difference between the trials ($F_{2,30}$ = .18; p >.05; $\eta 2$ =.01). The mean times for the sub-maximal warm-up, conventional warm-up and the no warm-up trials are described in table 1.

At gate one, no statistically significant difference in times, were recorded when comparing the times for the conventional warm-up to the no warm-up trial (1.98 ± 1.0 s versus 2.02 ± 1.2 s, p = ≥ 0.05). Similarly, when comparing the sub-maximal warm-up trial to the no warm-up trial a small difference was found, but no statistical difference was noted, (2.00 ± 1.1 s versus 2.02 ± 1.2 s, p = ≥ 0.05).

At timing gate 2, no statistical difference was noted when comparing the sub-maximal warm-up, conventional warm-up trial and the no warm-up group (7.56 ± 0.70 s, 7.54 ± 0.70 s, 7.74 ± 0.68 s, respectively).

The final gate was located at the finish line, so the data recorded total lap times in all trials. Again, times recorded showed marginal difference, but these were not statically significant (34.1 ± 3.70 s, 34.2 ± 3.70 s, 34.9 ± 3.58 s, respectively).

Table 1. Timings, in seconds, at each gate when compared to the no warm-up trial.

Trial	Gate 1	Gate 2	Gate 3
No warm-up (Trial 1)	2.02 ± 1.2 s	7.74 ± 0.68 s	34.9 ± 3.58 s
Conventional warm-up (Trial 2)	1.98 ± 1.0 s	7.54 ± 0.70 s	34.1 ± 3.70 s
Non-fatigue warm-up (Trial 3)	2.0 ± 1.1 s	7.56 ± 0.70 s	34.2 ± 3.70 s

4 Discussion

The study had three specific aims to 1) ascertain if a warm-up had an effect on BMX performance 2) whether a rest period post warm-up affected performance, and 3) if a sub-maximal warm-up could influence performance to a greater extent. The results from the study found no statistically significant difference between the trials, inferring warm-up had no impact on performance. The second aim established a 10-minute rest interval between warm-up and sprinting had no detrimental impact on performance and the third aim noted a sub-maximal warm-up had a similar impact on lap times as the conventional higher intensity warm-up

4.1 Effect of Warm-Up on Performance

In trials 2 and 3 riders performed active warm-ups which was compared to trial 1, the no-warm up trial. When comparing the result of the trials (see table 1), no statistical difference was found. However, while not significant, riders in the active warm-up trials (trials 2 & 3) were on average 1 second faster compared to trial 1. This may appear small and statistically not different, but when applied to race data it has a potentially important effect. For example, Rylands et al., (2017) analysed race results from 175 races in the 2012 BMX World Cup Supercross Series. The authors found that times between positions were minimal, for example the mean difference between 1st and 2nd place was 0.49 ± 0.36 s across the 175 races and from 1st to 3rd place 0.95 ± 0.57 s. From an applied perspective the current study infers that an active warm up could in fact aid a rider progression from 4th place in a final to a medals position. As such, the current study may be limited in statistical power by virtue of the small sample size (11 riders) used.

While statistical significance was not achieved, the practical implications of the findings should not be overlooked. This view has been noted by various authors for over the last decade. Cummings et al., (2014) stated that researchers should shift their investigations away from focusing purely on statistical significance and consider what is actually happening in the study. This is a view also shared by Bernards et al., (2017) who stated that researchers should not dichotomously focus on reject-non reject outcomes of a study, as this can impede scientific progress. Researchers should consider the data in the real-world context and look at statistical significance as an analysis aid, not a dichotomous tool.

4.2 Conventional Warm-Up (Trial 2)

Trial 2 aimed to compare the effect of a rider's conventional warm-up routine on performance. In an ideal world athletes can perform a warm-up and compete immediately post warm-up. However, as noted by Faulkner et al., (2013), Docherty and Hodgson (2007), Buttifant and Hrysomallis (2015), and Silva et al., (2018) this is not the case in many events. Athletes often experience delays between warm-up and competition, and these periods can be of sufficient time for a reduction in muscle temperature, which can affect performance. Delays between warm-up and competition are common in BMX cycling. A conventional warm-up on a race day involves riders warming-up on a static ergometer, after which they are called to a holding area by a race official. From the holding area they then move to the bottom of the stairs, which lead to the top of a start ramp. The whole process can take 10- 20-minutes depending on the location of team areas in relation to the holding area, delays in race schedule and crashes.

The delays between warm-up and competition have been found to negatively impact performance. Bishop (2003) found that sprint performance could be negatively affected if an athlete was inactive for just 5-minutes post warm-up. In a separate study Crowther et al., (2017) noted a 15 % reduction in recorded power outputs after 20-minutes rest post warm-up. However, despite Bishop's (2003) findings the current study (trial 2) found no detrimental impact on performance 10-minutes post warm-up. A possible rationale for trial 2 showing no negative impact may be a combination of time and clothing. Bishop (2003) stated that a warm-up needs to increase muscle surface temperature by 2 degrees. Within the current study here, the 10-minutes may not have been a long enough duration for the participant to reduce the muscle temperature by 2 degrees, the stated temperature that elicits a change in performance (Bishop, 2003). This could in part be explained by the clothing BMX rider wear. BMX clothing has safety padding which could act as a heat insulator maintaining the riders surface muscle temperature post warm-up. Studies have shown that clothing can be used, in the form heated suits, which act as a form of passive warm-up, these have been shown to have a positive effect compared to no warm-up (Ollano, 2023).

4.3 Sub-Maximal Warm-Up

Trial 3 looked at the impact of a sub-maximal warm-up on riders' sprint performance. Tomaras and MacIntosh (2011) noted that high intensity sprint intervals can have an accumulative fatigue effect on sprint performance. If any potential fatigue could be minimised through a low intensity warm-up, this would be a benefit to riders. Bishop (2003) stated for a warm-up to have a positive impact on performance, an athlete's muscle surface temperature needs to be raised by 2 degrees. If this can be achieved at lower intensities and the outcome is the same, but the fatigue effect minimalised, performance could be improved. The current study used a previously validated protocol from Mina et al., (2020) the author compared high and low intensity warm-up protocols and the effect on peak power. Mina et al., (2020) reported no difference in power between intensities, inferring a low intensity warm-up had the same effect as high intensity warm-up. Therefore, the aim of this trial was to analyse the effect of a low intensity warm-up on sprint performance. A standard BMX race may require a rider to perform 7 warm-ups in one day, as they will have to compete in 3 motos, 1/8, 1/4, 1/2, and a final. If these warm-ups are high intensity and in addition the riders are sprinting as part of a race, they could perform 14 high intensity efforts in a single day. If the number of high intensity efforts can be halved to 7 through low intensity warm-ups, the accumulative fatigue in a race day can potentially be reduced. However, the current study found no statistical difference between trial 1 and 3, but timing data showed a lap time of almost 1 second faster in this trial compared to the non-warm-up trial. Also of interest, the study found that the conventional warm-up and non-fatigue warm-up both recorded similar times. This infers that the non-fatigue warm-up could be used as an effective warm-up in BMX cycling, without the risk in inducing additional fatigue.

5 Practical Applications

If rider's base warm-up routines on personal experiences and conjecture, which was noted as common practice in many sports by Bishop (2003), there is a need for empirical studies to be undertaken in this area. Despite the current study not showing a statistical difference between the trials, the study did find some interesting results and pose a number of questions for future research. In addition, the applied nature of the study infers a BMX riders' pre-race routine could potentially move the rider to the next round or move them onto a podium position in a race final

The study also found that undertaking a sub-maximal warm-up can elicit a similar outcome as a conventional warm-up containing fatiguing sprints. This is a practical finding that can be easily used by coaches on a race day. In summary, coaches should consider incorporating sub-maximal warm-ups, such as those tested in Trial 3, to minimize fatigue during race days.

6 Conclusions

To the authors' knowledge this study is the only research that has looked at the impact of warm-up on performance in BMX cycling and is a starting point for future research in this area. The findings from this study warrant further investigation, such as what is the possible impact of accumulative warm-ups on fatigue, what is the effect of clothing on warm-up, does the riders' leg temperature increase and is it maintained by the padding in their race clothing acting as insulation and mimicking a passive style warm up?

Supplementary Materials: The following are available online at www.jsc-cycling.com/xxx, Figure S1: title, Table S1: title, Video S1: title.

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