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Adopting a Constraints-Led Approach to Enhance Skill Acquisition for Fast Bowlers in Grassroots Cricket

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Abstract

In this quantitative study, a bespoke coaching drill was designed and tested over 16 weeks to improve the bowling accuracy of 6 participant seam bowlers. This experiment consisted of 6 male participants with a mean age of 19.5 ± 7.5, mean height (cm) of 184.75 ± 5.57, and mean weight (kg) of 78.05 ± 9.87. Due to the repeated measures experimental design, paired samples t-tests were conducted to assess the effectiveness of this coaching intervention and compare performances between the "control" phase and the "training" phase. Results revealed that this purposely designed coaching drill led to a significant improvement in bowling lines ($p < 0.001$) with a moderate effect size and bowling lengths ($p < 0.001$) with a large effect size. However, this coaching intervention did not have any significant effect on bowling discipline ($p = 0.134$). Evidence proves that regular repetition of exercises over a prolonged time can ultimately enhance motor skill refinement. From a practical perspective, coaches can replicate the drill introduced in this study as a means of skill acquisition and skill refinement for their seam bowlers.

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INTRODUCTION

In competitive sports, every professional team or athlete works with a coach (or trainer) who facilitates and nurtures the progress of the athletes toward their goals through feedback, instruction, and numerous training methods organized in the build-up to a sporting event (Hodges & Franks, 2002; Otte et al., 2020; Potrac et al., 2000). Within team sports, a team of coaches (consisting of performance analysts and specialist coaches) usually analyze different facets of performance to develop the most appropriate information, hoping to develop a winning strategy (Bampouras et al., 2012; McGarry, 2009).

Classical coaching styles are often based on coach-centered, prescriptive methods with theoretical relations to information-processing approaches to defining motor performance (Côté & Gilbert, 2009). These approaches treat performance as being driven by prescriptive internal models, and practice is undertaken to fine-tune these models through learning over time. These internal models or representations, constantly informed through learning, yield an internal motor program with optimal movement patterns relevant to the task (Côté & Gilbert, 2009; Orth et al., 2019).

These types of coaching models have been passed down from generations of ex-players or coaches, utilizing anecdotal or procedural knowledge, intuition, and speculation (Bampouras et al., 2012; Harvey et al., 2013; Williams & Ford, 2009). In these approaches, the coach is the main instructor, prescriber, and director of the entire learning process and the athletes' performance capacities. However, this degree of emphasis often creates a learning environment that is coach-centered or teacher-centered rather than learner-focused. They also suffer from other drawbacks such as a lack of novelty and variability, monotonous repetition behaviors, and lack of task

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representativeness as the real-life task may require adaptation to unknown or unexpected stimuli, which may not have been internalized by the performer's motor program (Krause et al., 2018; Newman et al., 2022; Passos et al., 2008).

More modern coaching methods incorporate data from physiological, technical, tactical, and psychological performance indicators and notational data through video analysis. Furthermore, newer pedagogical frameworks such as the constraint-led approach (CLA) that focuses on the non-linearity of skill development and learner-environment relationships (Newell & Wade, 2018; Otte et al., 2019; Renshaw & Chow, 2019) or learner-centered game-based approaches such as teaching games for understanding (TGfU) are being increasingly utilized (Kinnerk et al., 2018). The constraint-led approach is based on the theoretical basis of ecological dynamics that treats skill development as a process that is driven by dynamic relationships or couplings created between the performer and various components that exist in the performance environment to create a functional ecosystem (Araújo et al., 2006; Orth et al., 2019; Roberts et al., 2019). It does not consider skilled performance as being a consequence of optimal internal models or representations but a result of attuning to specifying (and ignoring non-specifying) informational sources through exploratory processes that uncover various affordances (or opportunities) of action in the environment that the performer may exploit (Araújo et al., 2006; Krakauer & Mazzoni, 2011; Orth et al., 2019).

Given the emphasis of this approach on performer-environment relationships, the training environment associated with this approach would not be centered around the coach. The coach would act merely as a facilitator that manipulates constraints such that it helps the performer explore the performance environment in novel and challenging ways. For the training environment to be effective, it must recreate or simulate those opportunities for action, conditions, and constraints that may be available to the performer in the real-life task. This representativeness of learning design is imperative alongside manipulating constraints for the constraint-led approach to be effective.

Cricket coaching also involves the use of previously mentioned techniques. However, as there are two distinct specialties in cricket – batting and bowling, there are different technical methods of coaching that address the complexity of both tasks. Cricket batting, for example, is a highly technical interceptive task that requires high temporal and spatial accuracy and is considered one of the most complex motor skills to master (Penn & Spratford, 2012). That is why cricket batting is often taught through coaching manuals and textbooks created by ex-players and ex-coaches based on their knowledge and experience. While some of the information in these manuals has been tested for validity, other information has been deemed experiential, ambiguous, or non-empirical (Penn & Spratford, 2012). Therefore, some of the information contained within these coaching manuals and texts requires further contributions from scientific fields such as biomechanics, motor learning, and performance analysis (Penn & Spratford, 2012; Marc R. Portus & Farrow, 2011). Hence, there are still several open questions regarding optimal methods to reach the ideal interceptive stroke, such as breaking down the complex actions into smaller components and then combining them; action simplification through task modification (such as using a lighter ball that is easier to hit) and so on (Marc R. Portus & Farrow, 2011). While it is a positive development to see the attempted application of these techniques in studying and teaching cricket batting, there is still a lack of research on cricket bowling, especially from a coaching perspective.

Fast bowling research has picked up recently, but most of this research focuses on biomechanical analyses or injury prevention (Johnstone et al., 2014; Ramachandran et al., 2021). The few interventions designed for fast bowlers have also had physiological or kinematic aims like technique modification for back and shoulder injury prevention (Ranson et al., 2009), harness usage for reduced disc degeneration (Wallis et al., 2002), or cooling methods for reducing physiological load (Minett et al., 2012). Interventions relating to the improvement of fast bowling performance from a performance analysis perspective are scant, despite knowing how integral they are to team performance, as they are the enforcers of minimizing opposition runs and maximizing opposition wickets – both of which are important performance measures of bowling performance in cricket (Feros et al., 2018b; Jamil et al., 2021; Mehta et al., 2022). The accuracy of bowling, therefore, is critical to team success, and inaccurate bowling not only works to the batter's advantage in general but also carries penalties in limited-overs cricket formats, such as one extra run for the batting team and an extra ball for wide balls and no-balls (when the bowler oversteps the bowling crease or bowls an above waist high full toss). Furthermore, no-balls in limited-overs cricket carry the penalty of free hits (where the batter cannot be caught or bowled out for one ball). It is partly because of these reasons that fast bowlers have drawn attention from researchers recently, as the need for them to be accurate has increased, and their margins for error have diminished (Douglas & Tam, 2010). Additionally, previous research has emphasized the importance of teams having skilled fast bowling options due to the established link between successful team performances and these higher "rated" individuals (Wormgoor et al., 2010).

This study intends to examine the efficacy of a training intervention to improve the bowling accuracy and discipline of fast (seam) bowlers by using a simple method of focusing attention to bowl the ball at a certain spot (a rectangular zone) on the pitch. This study attempts to integrate principles of CLA by manipulating task constraints (introducing a marked rectangular zone on the pitch). This study involved conducting on-field experiments in the natural performance environment and instructions not to give directive or prescriptive feedback during the intervention process. Furthermore, the interplay of task and environmental constraints amongst participants (who are team-mates) may lead to a competitive dynamic that may also be observed in performance – something that has been acknowledged previously concerning team sports performance (Passos et al., 2016). The training drill introduced in this study looks to improve performance through better accuracy and bowling performance by assessing the frequency of wides (bowling accuracy in terms of bowling line), no-balls (bowling discipline) as well as the frequency with which bowlers landed the ball within a marked rectangular zone, previously identified by studies as the "good" bowling length where batters exhibit high levels of indecision with regards to their shot selection (Pinder et al., 2012).

METHOD

Experimental Design and Data

In this study, six male seam bowlers of mean age (19.5 ± 7.5), mean height (cm) of (184.75 ± 5.57) and mean weight (kg) of (78.05 ± 9.87) volunteered to participate. This sample size was deemed adequate based on previous similar research (Duffield et al., 2009). All participants, parents, and/or guardians (if a participant was U16 years of age) provided written informed consent before testing. All bowlers were right-handed. Data was recorded throughout 12 outdoor training sessions at a local recreational cricket club venue during a single season. In each session where a bowler participated, they were asked to bowl 24 balls (4 overs) each – representing a traditional bowling spell they would be required to bowl in a competitive setting. The same all-weather astroturf cricket pitch was used for all data recording. A marking was placed on a 5th stump line (6 inches outside the off-stump line) extending to the off-stump while being 6.5-7.5 meters away from the opposite bowling crease to where the bowlers bowled (see Figure 1).

Previous research has revealed bowling lines and bowling length as crucial factors that aid bowlers in fulfilling their objectives (Connor et al., 2020; Feros et al., 2018a; Jamil et al., 2022, 2023; Mehta et al., 2022). More specifically, research has revealed that bowlers should try to bowl what is referred to in cricket parlance as a "good length," which traditionally puts opposing batters in two minds about whether to shift their weight onto their front foot or back foot (Jamil et al., 2022). The region where batters have been known to exhibit this greater uncertainty is around 6.5-7.5 meters away from their stumps (Pinder et al., 2012). Furthermore, bowlers are often instructed to bowl in the "corridor of uncertainty" (Mehta et al., 2022). This corridor is considered to exist in-between the off-stump and just outside the stump – an area exhibiting low average runs for batters historically, as well as a zone where the coaching strategies of defensive or low-risk batting have been advised (Connor et al., 2020; Mehta et al., 2022).

Bearing this in mind, a coaching drill was designed with a scoring system, the chief purpose of which was to punish bowling that pitched outside the 5th stump wide indicator on the off-side as well as traditional off-side wides, leg-side wides, front foot no-balls, and waist-high no-balls. Furthermore, this coaching drill was designed to encourage and train bowlers to bowl on the indicated "good length ."Duct tape was used to make the marking to minimize the potential impact of contact with the ball and present a clearly visible target. Wide indicators already marked on the pitch (as is traditionally the case) were used to determine wide balls on the off-side. Any ball bowled where the trajectory was across and behind the leg stump was deemed a leg-side wide. For the first six sessions (the control phase), all bowlers were unaware that data were being collected on their performances and what the markings on the surface represented. In between training sessions six and seven, all bowlers were fully informed of the scoring system and the purpose of this study (but not informed of their scores from the previous six training sessions). During sessions 7-12 (the training phase), all bowlers continued to bowl 4-over spells. The best three performances from the control and training phases were used for each bowler examined in this study.

For each aspect of performance examined (accuracy, discipline, and good lengths), only the data related to that aspect were examined, ensuring that each performance aspect was assessed in isolation. For example, in the case of bowling accuracy, only negative scores resulting from wide bowling were assessed – meaning that the three highest negative scores from each phase for each bowler were examined, and all other data were excluded. A similar procedure was followed when assessing bowling discipline and bowling good lengths. All data recorded during rain-affected training sessions were also excluded (only data recorded from completed training sessions were included). Data collection took place over 16 weeks. Data were collected live by three performance analysts who shared data collection responsibilities. Recorded video feeds were later used to review a random selection of 6 completed overs to test the reliability of the scoring procedure - a low percentage error of 3.48% was discovered, implying that the data utilized in this study is reliable. Ethical approval for this study was obtained by the ethics committee of the local institution (RETH(S)21/045).

Bowler Scoring System

BLACK ZONE* = 10 points (Bullseye), 6.5 - 7.5 metres away from the stumps (batter's side) in line with the off stump, the 4th stump and 5th stump lines

YELLOW ZONE* = 5 points, bowling in line with the 3 stumps, 4th stump and 5th stump, but over or under pitching the delivery

GREEN ZONE* = -2 points, bowling beyond the 5th stump line (to the left of the black tape) up to the wide indicator on the pitch on the off-side

RED ZONE OFFSIDE = -10 points, a wide down the off-side (pitching outside the wide indicator)

RED ZONE LEGSIDE = -10 points, a wide down the leg side (pitching outside the leg-stump)

NO BALLS = -10 points, all front-foot and waist high no balls.

*on any occasion when a ball pitches on green, yellow or black zones, but the trajectory continues to take the ball in to the red zones on either the offside or the legside then it must be marked as **-10 points** and as a wide.

Figure 1. Bowler Scoring System Used to Assess Performances

Statistical Analysis

Paired samples t-tests were conducted to examine the coaching drill's impact on bowling accuracy (wides), bowling discipline (no-balls), and good length bowling. Differences in observations were checked for approximate normal distribution (Rietveld & van Hout, 2017). Regarding bowling accuracy, the differences in bowling scores between the control/training phases were revealed to be normally distributed (Shapiro-Wilk, $p = 0.554$). In the case of bowling discipline, the differences in bowling scores between the control/training phases were revealed to be non-normally distributed (Shapiro Wilk, $p = 0.024$), and therefore, bootstrapped samples were used, with a thousand repetitions and bias-corrected and accelerated (BCa) 95% confidence intervals. In the case of bowling at a good length, the differences in bowling scores between the control/training phases were revealed to be normally distributed (Shapiro-Wilk, $p = 0.924$). Cohen's d effect sizes were also calculated and interpreted using the widely used thresholds of trivial < 0.2, small 0.2–0.6, moderate

0.6–1.2, large 1.2–2.0, and very large > 2.0 (Hopkins et al., 2009). All statistical analyses were performed using IBM SPSS version 25 (IBM Corp. Released 2017. IBM SPSS Statistics for Macintosh, Version 25.0. Armonk, NY: IBM Corp).

RESULTS AND DISCUSSION

Result

The results of this analysis are presented in Table 1 below. The results for bowling accuracy revealed a statistically significant difference in bowling performances between the control and training phases ($p < 0.001$). This coaching drill moderately affected bowling accuracy (cohen's d = 0.901). The results for the bowling discipline revealed no significant differences in bowling performances between the control and training phases ($p = 0.134$). This coaching drill had no significant effect on bowling discipline. The results for bowling at a good length revealed a statistically significant difference in bowling performances between the control and training phases ($p < 0.001$). This coaching drill greatly affected bowling good length deliveries (cohen's d = 1.247). The mean differences between bowler scores in each phase for each performance aspect are presented in Figures 2, 3, and 4 below. The mean differences were -34.667 for bowling accuracy, -3.889 for bowling discipline, and 41.278 for bowling on a good length. The mean bowler scores increased in the training phases for all three aspects of performance; however, they only significantly increased for bowling accuracy and bowling on a good length.

Table 1. Paired Samples t-test Results and Cohen's d Effect Sizes

Performance aspect tested	Significance Level (Control and Training)	Effect sizes
Bowling accuracy	p < 0.001	0.901 (moderate)
Bowling discipline	p = 0.134	-
Bowling length	p < 0.001	1.247 (large)

Figure 2. The Cumulative Differences in Average Scores between the "Control" and "Training" Phases for Bowling Accuracy

Figure 3. The Cumulative Differences in Average Scores between the "Control" and "Training" Phases for bowling Discipline

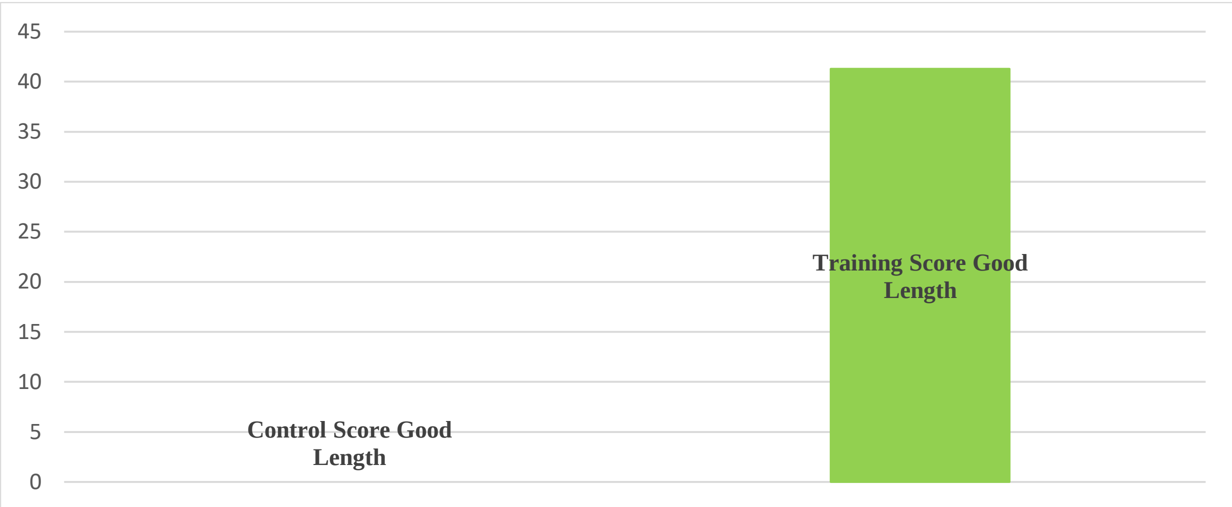

Figure 4. The Cumulative Differences in Average Scores between the "Control" and "Training" Phases for Bowling Good Length

Discussion

This study aimed to investigate what impact a purposely designed coaching drill had on three aspects of bowling performances: wide, bowling no-balls, and bowling on a good length. The results revealed that this coaching drill significantly impacted two of these three aspects of performance, specifically, bowling wides (moderate effect) and bowling on good lengths (large effect). The results also revealed that this coaching drill did not significantly impact bowling discipline.

The constraints-led approach has long been considered a suitable framework to inform coaching practice (Orth et al., 2019). With this approach, it is the coach's responsibility to shape and manipulate constraints so that practice consistently improves the learner's capabilities to perform in a range of competitive scenarios (Orth et al., 2019). Utilizing target-focused practice methods for acquiring or further developing various technical skills is not a new phenomenon. Researchers have frequently used target practice methods to assess the abilities and skills of athletes in numerous sports. For example, in football (soccer), numerous studies on penalty kick accuracy have discovered that accuracy can be improved when takers are presented with visual targets in each top corner of the goal (Navarro et al., 2013, 2018).

Similarly, visually moving targets have also been used to test the essential soccer skills of passing, dribbling, and shooting (Hoye et al., 2019). In golf, visual targets have been frequently used to assess putting ability (Moffat et al., 2018; Palmer et al., 2016). The target-focused practice has also been previously utilized in cricket. In a study by Portus, bowlers were instructed to bowl towards a visible target with three scoring zones of 100, 50, and 25 points (M. R. Portus et al., 2000). It was discovered that bowling accuracy deteriorated after bowling spells (M. R. Portus et al., 2000). A similar approach was adopted by (Duffield et al., 2009), where bowlers were required to perform a 4-over skills test. Bowlers were required to bowl a mixture of good length, yorker, and bouncer deliveries in a pre-designated order at a grid-based target, and bowling accuracy was rewarded using a points-based scoring system (Duffield et al., 2009). In a study by Phillips et al., pace bowlers were required to bowl 30 balls at match intensity towards a rear-projected image of a right-handed batter on a screen (Phillips et al., 2012). This skills test measured the bowlers' ability to hit specific targets, upon which they would achieve scores between 1-100 depending upon their ability to manage this action successfully. Yet another assessment of bowling accuracy was conducted (Glazier & Wheat, 2014), using a visible target sheet in line with the stumps at the batter's end of the pitch. Therefore, visual target-based practice methods have been frequently used to refine athlete skills, and the results of this study lend further support to their continued use.

Another potential explanation for the results obtained in this study could be the enhanced level of intrateam competition induced by revealing the scoring system to participants before the start of the training phase. Healthy intrateam competition is generally welcomed by coaches and is considered to improve collective team performances, enhance individual performance, and enhance team cohesion (Harenberg et al., 2016). Intrateam competitiveness can increase by designing task constraints representing specific sub-phases of competitive performance environments (in this case, bowling a 4-over spell in tandem with a bowling partner) (Passos et al., 2016). Creating this competitive environment within the team can encourage athletes to develop their technical skills and tactical knowledge to increase their chances of selection for the senior/first team (Passos et al., 2016). Coaches frequently use the generation of intrateam competition as a practice tool, which they can then manipulate or modify to accomplish numerous technical and tactical purposes (Harenberg et al., 2016). Introducing intrateam competitiveness can also help mimic the intensity of actual matches and increase motivation and effort levels in practice as it breaks the monotony of general skill training (Harenberg et al., 2016).

It is also possible that prolonged repetition of this exercise by the participants led to some skills retention, which contributed to the significantly improved accuracy scores obtained in the training phase. Previous research has revealed that learning and acquiring some complex motor skills can be performed effortlessly through repeated practice (Doyon et al., 2003). As the mastery of new skills requires considerable time and practice, much research has been conducted investigating different methods to improve the rate at which motor skills are learned, including approaches such as the one utilized in this experiment - offering learners rewards and/or punishments (through the scoring system) (Vleugels et al., 2020). Ultimately, the results of this study provide further evidence that prolonged, repeated practice can aid the refinement of motor skills. Rather interestingly, according to the results of this study, offering bowlers rewards (points) for bowling a good line and good length prompts improved collective bowling performances. In contrast, the same cannot be said for bowling discipline, as no significant differences were discovered. In addition, even making bowlers aware of the punishments (points deduction) for poor discipline resulted in no significant changes in performance, potentially presenting an interesting theme for future research.

The results of this study could also have been partially explained by directing the participants' attention externally, which previous research has revealed can significantly improve motor skill performance (Porter et al., 2013). Specifically, as participants were given verbal instructions before the training phase to aim for the visual target and consider where the ball would eventually end up, their focus could have potentially enhanced. Previous research on skill acquisition in sports such as basketball, volleyball, golf, and soccer has revealed that providing athletes with instructions that induce an external focus of attention (whereby they consider the impact of their movements on the environment rather than their movements themselves) can present learning benefits (Wulf & Su, 2007).

It should be noted that this study was not without its limitations. Firstly, there was no specific retention phase or retention testing in this experiment due primarily to the numerous training sessions within the season being adversely affected by the weather and the relatively short season. Secondly, all volunteer participants were right-handed bowlers, and the scoring system zones were accordingly devised under the assumption they were bowling to a right-handed batter. Further research is required to ascertain whether the coaching intervention introduced in this study impacts bowling performances when accounting for the right-hand, left-hand bowling/batting match-up dynamic. Furthermore, although all data collection took place during official training sessions on Tuesday evenings, there were no controls to prevent the participants from "extra practice" between training sessions. Future research, therefore, could investigate the level of skill retention after implementing such coaching drills as the one presented in this study and also apply additional controls where possible to limit skill acquisition opportunities between phases.

CONCLUSION

This study tested the effectiveness of a bespoke coaching drill designed to improve bowling accuracy in terms of bowling line, length, and discipline. Significant differences were discovered between the control and training phases for bowling accuracy (moderate effects) and bowling at a good length (large effects). However, this bowling drill had no significant effects on bowling discipline. Ultimately, this constraints-led approach facilitated the learning and refining of specific bowling skills of cricketers at the recreational level. Further evidence is discovered proving that the regular repetition of exercises over a prolonged period can ultimately enhance motor skill refinement. From a practical perspective, fast bowlers who perform at the recreational level should be encouraged to replicate the training design introduced in this study to enhance their bowling skills. Furthermore, coaches should be encouraged to manipulate constraints appropriately to facilitate athlete learning.

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AUTHOR CONTRIBUTION STATEMENT

MJ was responsible for preparing the final manuscript and was involved in the data collection procedures. LW was heavily involved in the data collection procedure. SM was responsible for recruiting volunteer participants for this experiment and was also involved in data collection procedures. SAM was involved in the manuscript preparation. DM was involved in a supervisory role. AM was involved in the experimental design and also in a supervisory role.

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