AN ASSESSMENT OF THE PHYSICAL FITNESS DEMANDS OF ONE-DAY CRICKET USING GLOBAL POSITIONING SYSTEM TRACKING SOFTWARE

Zane Webster

3001759

A thesis submitted in fulfilment of the requirements for the degree

MA (Sport, Recreation and Exercise Science)

in the department of Sport, Recreation and Exercise Science at the

University of the Western Cape

Supervisor: Professor A Travill

November 2017

ABSTRACT

Cricket is a highly technically skilled-based game, which consists of four distinct disciplines (batting, bowling, fielding, and wicket keeping) with varying physiological and biomechanical demands. There are three standardized professional versions of the game, namely, test match or multi-day cricket, limited overs or one-day cricket and Twenty-20 or T20 cricket. One-day games consist of two innings with each team getting a chance to bat and bowl. One innings encompasses fifty overs and the game generally lasts for approximately 6 hours. Although research has been conducted on the physical demands of cricket, not many studies compare the differences of these demands between different playing positions. Furthermore, there is a lack of research around the differences between professional and amateur level cricket players.

This study was conducted in the Western Cape, South Africa, and utilized arithmetical data to analyse the physical demands of one-day games and training sessions preceding these games. A University team (amateur) and Provincial teams (professional) were used to collect data for this study. A one-way ANOVA was conducted to test for differences between sub-disciplines (batsmen, fast bowlers, spin bowlers, fielders, and wicket keepers) in terms of their training loads and match loads. A post-hoc Tukey test was done to establish which means were significantly different from each other with the level of significance set at $p<0.05$.

Results gathered from this study revealed that there are significant differences across all playing positions in terms of movement patterns, movement variables as well as physiological responses during training and one-day games at both university and

provincial level cricket. It also highlights significant differences between training and match demands across all playing positions at both university and provincial level cricket. Results also show that cricket players do not meet the demands of a one-day game during training sessions preceding that game. Furthermore, it showed that fast bowling is the most physically demanding playing position at both university and provincial levels of cricket. In relation to differences between varying levels of cricket, this study exhibited that university cricket players are under greater physical demand during training while provincial cricket players are under greater physical demand during a one-day game. Based on the outcomes of this study it is clear that coaches and trainers should develop training programmes, which are aligned with the demands of the games and of the different playing positions identified in this study. Game-based training should therefore also form part of the training regimes of teams.

DECLARATION

I hereby declare that the totality of the work confined therein is my own, original work, that I am the owner of the copyright thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

3/07/2018

Signature: Zane Webster Date

DEDICATION

This thesis is dedicated to my parents without whom I would not have reached this point in life. Through your love, support, and sacrifice I have been afforded the opportunity, which both of you never had, to further my education and pursue my dreams and passion. I will always be grateful for having you in my life and I hope you can be as proud to have me as a son as I am to have you as my parents.

ACKNOWLEDGEMENTS

Up to this point in life, I have been privileged enough to have lived what I feel is a very good life. From growing up playing in the streets with friends, to experiencing life overseas for a few months. I have lived through many highs as well as lows. The completion of this thesis, however, is ranked amongst the greatest achievements in my life thus far. In life, we come across many different people and places that contribute to our successes and failures, to all that have had a significant contribution to my life I say thank you, although a few people need to be highlighted in this regard.

To my supervisor Prof. Andre Travill, you are the only person I have worked with thus far in my post-graduate life and for that, I am grateful. Without your hard work and dedication, none of this would have been possible and I am eternally indebted to you for your efforts.

To the team of Sports Skills for Life Skills and UWC Cricket Club, you guys have been my family, my home away from home during my time as a student at UWC, for this I thank you. Cricket was the initial reason I chose to study at UWC and if not for your outstanding history as a club I would not have been attracted to the university and attained what I have on and off the field of play. Without the financial support, you have provided for me none of this would have been possible as well.

To my close family, we have never been what media would perceive as "One Big Happy Family" but I would not change a thing about who and what we are. To me family is everything, I have not always seen it but your continuous love, understanding, and support through my years of education is what kept me going a lot of the time.

To the Department of Sports, Recreation and Exercise Science, you laid the foundation for what and where I am today in the field of sports science. When I arrived at the university, I was an aspiring professional cricket player and you showed me another path. The support and guidance from staff and peers is something I can never repay.

To my best friend Steve Fielies, we began a journey together nearly 8 years ago now, from bunking classes in first year to both of us doing a Master's Degree, who would have ever thought. No doubt, I would not have reached this point without your friendship and I hope it continues for a lifetime and beyond.

To my wonderful wife Raeesa Webster, my rock, you are supportive without despondency, relentlessly loving, caring and kind. Thank you for being my light in the difficult times faced over the last few years and never letting me give up. With you, by my side, I know anything is possible.

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER 1

INTRODUCTION

"Cricket is all about how you perform on the field. It is a mental game and how well you display

your talent depends on one's confidence."

Bob Woolmer (1948-2007)

Cricket, in the past, was widely perceived as a sport that did not require a great deal of physical fitness, with many players, especially at club level being overweight (Christie, 2008). However, with the game evolving constantly over the last two decades, the physical demands have risen immensely with fixtures being a lot more clustered together as well as many more competitions being played forcing coaches and players to focus more on the physical demands of the game. In 1998, the South African national team spent 99 days playing cricket (Noakes & Durandt, 2000).

There are three standardized professional versions of the game, namely, test match or multi-day cricket, limited overs or one-day cricket and Twenty-20 or T20 cricket. One-Day Games (ODGs) consist of two innings with each team getting a chance to bat and bowl. One innings encompasses fifty overs and the game generally lasts for approximately 6 hours.

The sport of cricket consists of four very distinct disciplines, each with its very different skill and fitness demands. The four disciplines or areas of play are batting, bowling, fielding, and wicket keeping. Each one requires different movement patterns but is similar

in the physical movements. When batting, bowling, fielding and wicket keeping, one is required to sprint, accelerate as well as expend short bouts of energy at high intensity (Petersen, Pyne, Dawson, Portus & Kellett, 2010). Examples of these are throwing when fielding, striking the ball when batting and delivering the ball when bowling. Even though there are similarities, with the differences in movement patterns one could assume that the intensities at which these skills are performed are different and have different physical demands. However, evidence to support this assumption is scarce.

Information regarding the physical demands of cricket has mostly been obtained from research conducted in simulated settings, which in theory, cannot be a true reflection of the demands of the real match situation. Furthermore, there is a dearth of information of the physical demands of cricket training compared to that of a match situation. Taking this into consideration, the question which comes to mind is whether or not cricket players are meeting the physical demands of cricket during training to perform at optimal level during competition. Despite significant advances in technology and an increased research focus on cricket, there is limited information available regarding the physical demands of cricket, especially during competition.

Sports scientists require accurate information and an in-depth understanding of the physical demands of cricket in order to develop and design appropriate training strategies and programmes. A wide variety of techniques are available to assess and estimate the physiological and physical fitness demand of different sports ranging from simple pen and paper methods and video recordings, to sophisticated electronic tracking devices (Edgecomb & Norton, 2006). Global Positioning System (GPS) technology is an electronic

tracking device, which is designed to track movements of players by means of satellites and radio transmitters as well as receivers around the pitch. The GPS allows for real-time data and records performance on a video tracking system. This data is then stored and downloaded onto a computer for analysis after use. Historically it has been difficult to analyze the frequency and intensity of physical exertion that affects players in fieldbased sport. However, by using GPS units, conditioning coaches can not only choose the most conditioned players but also provide accurate data for the coaches to adapt their conditioning programmes in order for the players to reach their peak during matches (Cunniffe, Proctor, Baker & Davies, 2009).

At present, the game of cricket has been significantly enhanced by improving performances and administering injury prevention frameworks among cricket players from the use of technology, sports sciences and other mechanisms (Noorbhai & Noakes, 2015). Although research in the field of sports science has evolved a lot in the last decade, not many studies have been conducted on the physical demands of cricket and its relationship with that of fitness training programmes, using advanced technology. A review conducted by Scanlan, Berkelmans, Vickery and Kean (2016) on the internal and external physiological responses to batting, proposed that future research should combine these measures during actual gameplay, as well as comparing different game formats and playing levels.

Although many methods of training have been developed to account for the increase in physical demands, not a lot of evidence exists to indicate how effective and aligned training is with the physical demands of the various competition formats of the game. The aim of this study was, therefore, to investigate the physical demands of cricket, by using GPS

units, during a competitive ODG and to compare this to physical demands of cricket training for both provincial and amateur players. Furthermore, it aims to investigate possible differences, if any, between the physical demands of various disciplines within the game in competition and during training as well as the differences between provincial and club players.

1.1 Statement of the Problem

Cricket is a highly technically skilled-based game; therefore coaches generally focus on the improvement of these skills during training sessions. However, there is a certain level of physical exertion required to execute these skills optimally, which tend to be dismissed during training. This could lead to players being physically unprepared for the demands of a match. Since cricket consists of different "sub-disciplines" it is likely that due to the different movement patterns, physical and physiological demands of the different disciplines that, participants will display different levels of physical fitness. Pote and Christie (2016) suggested that although cricket is one of the world's major team sports, it has received very little research attention particularly with regard to the physical demands of the game and how that relates to the demands of the physical training the players are subjected to. The purpose of this study was, therefore, to assess and compare the physical demands of ODGs and cricket training sessions, using GPS units.

1.2 Aim

The aim of this study was to provide a quantitative description and comparative analyses of the movement patterns and demands of pre-game training and ODGs of university and amateur provincial male cricket players.

1.3 Objectives

The objectives of this study include the following:

- To determine the physical demands of a ODG using GPS units for both a university and a provincial cricket team.
- To determine the physical demands of cricket training programmes using GPS units of both a university and a provincial cricket team.
- Compare the physical demands of training sessions with that of games for both provincial and university players.
- Compare the training and game data of the different disciplines i.e. batting, bowling, fielding and wicket keeping both within and between university and provincial players.

1.4 Hypothesis

It is hypothesized that:

- The physical demands of players during training sessions are less than during games for both university and provincial teams.

- The physical exertion between training sessions and games will be more closely matched at provincial level than at university level.
- The physical exertions will differ between the four disciplines namely batting, bowling, fielding, and wicket keeping both within and between university and provincial players.
- The physical demands for provincial players during both games and training will be higher compared to university players.

1.5 Significance of the Problem

Physical fitness is strongly related to sports performance. This means that the physical fitness of sportspersons will affect their ability to function optimally, especially as is relates to sport. Pote and Christie (2016) found that incorrect conditioning practices are being focused on in cricket, that coaches are monitoring physical fitness out of necessity and are not committed to improving specific weaknesses that may be exposed through testing practice. It is expected that eventually, with knowledge that is more detailed it will be possible to advise athletes scientifically in choosing exercise programmes which would be most beneficial to them individually. The results of this study will reveal a set of reference values, which will be useful in investigations on player selection, training programme development for teams as well as individual athletes within those teams (Petersen, Pyne, Portus, Karppinen & Dawson, 2009). The results of this study may assist coaches and sports scientists with the design individual position-specific training programmes in accordance with the match demands of cricket (Cunnife, et al., 2009).

1.6 Definition of Terms

Cricket: Cricket is a game played with a bat and ball between two teams of eleven players on a field, at the center of which is a rectangular twenty-two-yard pitch. Each team takes turns to bat and field, and each turn is called an innings.

GPS Technology: GPS (Global Positioning System) technology is a tracking device, which is electronically designed to track movements of players by means of satellites and radio transmitters as well as receivers around the pitch.

Physical Fitness: Physical Fitness is a general state of health and well-being or specifically the ability to perform aspects of sports or occupations.

Batting: Batting is an individual standing at one end of the pitch and receiving a delivery from the other end, which he tries to hit and accumulate as many runs as possible.

Bowling: Bowling is the action of propelling a ball toward the wicket defended by a batsman. It is distinguished from throwing by a strictly specified biomechanical definition, which restricts the angle of extension of the elbow.

Fielding: Collecting the ball after it is struck by the batsman, in such a way either to limit the number of runs that the batsman scores or to get the batsman out by catching the ball in flight or running the batsman out

Wicket keeping: The player who stands behind the wicket or stumps, being guarded by the batsman currently on strike. The wicket keeper is the only member of the fielding side permitted to wear gloves and external leg guards.

Physiological Response: An automatic reaction that triggers a physical response to a stimulus.

Anaerobic energy system: The Anaerobic energy system produces energy in the absence of oxygen, during high intensity and initial phase of physical activity.

Aerobic energy system: The Aerobic energy system produces large amounts of energy at low intensity with the presence of oxygen.

CHAPTER 2

LITERATURE REVIEW

The use of science and technology in sports have helped teams, individuals, coaches and trainers to continually improve and advance the levels of performance in various sports around the world. Evidence of these advancements is seen in records being broken and new standards being set frequently. This chapter reviews the physical demands of cricket and compares these demands between different disciplines of the game namely batting, bowling, fielding, and wicket keeping. Furthermore, it will review various training methods used in cricket as well as the use of GPS technology to monitor movement patterns and physical exertion in sport and how this type of information can benefit sports performance and training.

2.1 Physical Demands of Cricket

Cricket, in the past, was widely perceived as a sport that did not require a great deal of physical fitness, however recent studies reveal that the physical demands have increased considerably over the past two decades (Christie, 2008; Noakes & Durandt, 2000). More recently, Anand (2016) discussed variables of medicine ball training and how it can benefit cricket players and suggested that cricket is an intermittent field sport that requires explosive power production. This suggests a method of training that could be crucial to optimal performance. Physiologically, cricket is an aerobic sport with periods of anaerobic activity that requires explosive power to intermittently perform explosive activities of various natures (Anand, 2016).

Aughey (2011) who investigated the applications of GPS technologies in field sport found that cricketers regardless of the distance traveled to spend a greater amount of time walking than any other component of locomotion. When compared to other field sports there is a low percentage of high intensity running but a large sprint component. Petersen et al, (2010) agree with these findings and added that the volume of sprinting is dependent on circumstances within the game. Lockie, Callaghan and Jeffriess (2014) who analyzed the first two steps of a 10-m sprint in experienced cricketers and its implications on-field performance, found that sprints during cricket are often centered about crucial match situations such as running between the wickets, the run-up, and delivery during fast bowling, or sprinting to field a ball. Due to the unpredictable nature of cricket, it cannot be pre-determined how many sprints or high-intensity bouts a player will have to perform during a match, however through careful monitoring and analysis, a better understanding of what is required when training can be revealed. According to Aughey (2011), higher intensities were seen in the shorter formats of the game for all sub-disciplines. This suggests high-intensity training is needed for game preparation in order to perform optimally. This is supported by Petersen et al, (2010) who found that time spent sprinting per hour is 50% to 100% more in one day cricket than in multi-day cricket. However, they also report that although shorter formats require greater intensity per unit time, the multi-day format still has a greater overall physical load due to the difference in duration of the games. To further support this they state that for all sub-disciplines, recovery time between bouts of high intensity, are higher in one day cricket than in multi-day cricket. Scanlan et al. (2016) said that the oxidative energy system likely plays major roles not only in adenosine triphosphate resynthesis, but also in phosphor-creatine (PCr) restoration and lactate

oxidation during lower intensity activity, which suggests that a well-conditioned aerobic capacity is advantageous for cricket players during recovery from high-intensity efforts.

With regards to research comparing training and match demands, Vickery, Duffield, Crowther, Beakley, Blanch and Dascombe (2018) conducted research to determine which training method (net-based sessions or centre-wicket simulations) currently used in national level and U19 male players cricket, provided a more physical and technical match-specific training response. Parts of the findings suggested that regardless of playing position, differences in physiological demands between training modes and match-play were unclear, with the exception of higher heart rates infielders during traditional net sessions. This suggests that physical exertion was higher during training. Vickery et al. (2018) also found that during center-wicket simulations, demands were similar or greater when looking at distance traveled at a high-intensity within each playing position. Overall, it supports the notion that teams aren't training correctly in terms of matching the load between practice and competition. Pote and Christie (2016) stated that the rapid transformation of the game cricket has added to player workload, resulting in an increased risk of injury, which places emphasis on adequate physical preparation as both over training and under training could increase the risk of injury. Pote and Christie (2016) also displays areas of the body where the most common injuries between the different sub-disciplines or specialist positions in cricket.

Lockie et al. (2014) found that generally in a cricket match, the square boundaries are a minimum of 137.16 m apart, with the shorter of the two being a minimum 59.43 m from the center of the pitch and the straight boundaries at both ends of the pitch are a minimum

of 64 m from the pitch center. Information like this could help coaches plan training sessions by giving them parameters in which to work with.

Looking at the importance of position specific training, Vickery, Dascombe and Duffield (2016) who examined the relationship between session Rating of Perceived Exertion (RPE) and measures of training load (TL) within cricket batsmen and medium fast bowlers during net-based training sessions found that position-specific responses are evident, and should be considered when monitoring the TL of cricket players. This notion is supported by Noorbhai and Noakes (2015) who suggested due to the variability of findings in both batsmen and bowlers; it is highly putative for each cricket player to be regarded as an individual with eliminating a 'one-size fits all approach. Furthermore, Anand (2016) mentions that physiological and biomechanical requirements of cricket vary greatly depending on the format and the positions of play. Cricket coaches generally have all members follow the same programmes for physical conditioning and only separate when specific skills are being trained; however, the evidence found highlights the importance of separating and specifying conditioning programmes based on the player's individual position demands. Within the confines of the high-performance team sports environment, as a result of training load monitoring practices, it is common to prescribe more individualized player training programmes specific to their respective match demands (Vickery et al., 2016). According to Noorbhai and Noakes (2014), despite great advancements in science and performance in cricket, there is still a gap between skill improvement and injury prevention methods; furthermore, they suggest that the way

forward in cricket research requires main elements such as performance, prevention, and psychology in cricket to be applied as one holistic-systematic model.

Contemporary conditioning programmes are based on detailed knowledge of a sport's movement patterns and physiological demands (Petersen et al., 2010). This is highlighted by Petersen et al. (2009) who investigated the validity and reliability of three commercial GPS units. Findings from this study reveal that quantifying movement patterns based on game demands are important in developing sport-specific conditioning programs and adapting the length of recovery periods from game and training activities. This will allow for more game specific activities to be prescribed by conditioning coaches during training, therefore preparing players more effectively for games.

Further investigation into the differences in physiological demands of various positions by game and format need to be done. Comparisons between the pathways of progression from amateur to professional level cricket need research attention as well (Petersen et al., 2010).

2.2 Differences between Sub-Disciplines

2.2.1 Batting

A study conducted by Noakes and Durandt (2000) on the physiological demands of cricket found that when batsmen during a one-day cricket match, bat for 100 runs, and who batted with other batsmen who also scored 100 runs in the same period, based on the probable distribution of the numbers of one, two, three and four runs scored, each batsman would run 3.2 km approximately in 8 minutes. Hence, the overall running speed would be 24 km-1. This indicates that both disciplines require some form of aerobic and anaerobic fitness.

However, according to MacDonald, Cronin, Mills, McGuigan and Stretch (2013) recent research has indicated that cricketers generally rely on aerobic energy supply and that the rates of energy expenditure of cricket are relatively low with the exception of this being fast bowlers during a bowling spell and fielders sprinting after the ball his generalization is supported by the findings of time-motion analyses. This indicates that there is an element of both the aerobic and anaerobic energy systems involved in the game. This is supported by Stretch, Bartlett and Davids (2000) who evaluated the scientific research into the morphology and physiology of cricket batsmen. They found that energy for cricket activities are supplied by anaerobic sources however the replacement of the phosphate stores during recovery are supplied by the aerobic energy sources. Other factors such as sufficient nutrition and replenishment of key sources of energy also play a role in the performance of players. Scanlan et al, (2016) found that carbohydrates were the preferred source of energy substrate during batting tasks.

Duffield and Drinkwater (2008) conducted a time-motion analysis of Test and ODG (international) cricket centuries and found that when scoring a one-day century batsmen spend a large amount of time in low-intensity modes of standing, walking, and to a reduced extent jogging. This suggests that batting is not very physically demanding. Scanlan et al. (2016) supports this by stating that literature indicates majority of batting time is spent engaged in low-intensity activity.

However, Pote and Christie (2014) found when quantifying the physiological and perceptual demands of repeated single shuttle sprints between the wickets during batting, resulted in the plateauing of physiological responses (heart rate and VO2) and ratings of

perceived exertion continued to increase over time. The testing, however, took place in a laboratory setting, which could question the game-specific effect physically. Scanlan et al. (2016) give further evidence which suggests a predominant recruitment of aerobic metabolic pathways after 4 sprints in the first over (out of 7 overs), indicating anaerobic energy systems are also important during the short high intensity running bouts and likely contribute to sustained elevated physiological responses thereafter. Looking further into the physiological effects of batting, Scanlan et al, (2016) showed that players reached 97% of maximal heart rate (HRmax) and spend considerable proportions of batting time (63%) working above an intensity of 75%. HRmax periodic bursts of high-intensity efforts are required, which indicates anaerobic energy stores are relied upon mostly and emphasizes the need to have well-conditioned anaerobic energy systems. Other factors to consider are the implications that protective equipment used when batting has on the movement patterns of players. Batters are required to do a great deal of running during competition depending on the circumstances of the match, however during most training sessions, batsmen spend most of their time not running at all during net sessions. In theory, a certain amount of conditioning with equipment on should take place in order to optimize performance, as the equipment does affect the ability of batsmen to run. Webster and Roberts (2011) who conducted a study on the effect of leg guards on running performance supported this. They found that wearing cricket pads has a negative effect on straight-line running performance compared with running without pads.

Although few studies have been done in this area, the summary of data provides important insight regarding physiological responses to batting and highlights that more research on this topic is required (Scanlan et al., 2016).

2.2.2 Bowling

Fast bowling is generally considered the most physically demanding of all the disciplines. Research conducted by McNamara, Gabbet, Naughton, Farhart and Chapman (2013) on key fatigue and workload variables of cricket fast bowlers and non-fast bowlers found that the median distance covered by fast bowlers was greater than that by non-fast bowlers in both the physical preparation and competition. Furthermore, fast bowlers were found to consistently perform at greater intensities and performed more bouts of high-speed running than non-fast bowlers (MacNamara et al., 2013). This suggests that fast bowling is the most physically demanding of the sub-disciplines.

Noakes and Durandt (2000) found that an estimate of the physical activity in bowling during one-day cricket suggested fast bowlers deliver about 64 deliveries (60 legal and 4 wides or no balls) in 40 minutes. During this time, they are expected to, in theory, run 1.9 km in about 5.3 minutes, an average speed of 21.6 km/h.

Looking further into the demands of bowling and what is required during training to perform optimally during competition Mount, Moore and Ranson (2015) investigated match and training workload patterns across all formats of international cricket and found that ODGs, as well as practice matches, had the highest mean workload per day (45 balls), compared to training (33 balls). This indicates that bowlers, on average have a lighter

workload during training when compared to matches. However, Vickery et al, (2016) found that fast bowlers delivered a greater number of balls during net-bowling compared to a match, which is contrast to what Mount et al, (2015) found one session indicating under training and the other overtraining. Both under bowling and over bowling increase the risk of injury. Measures of ball frequency, ball effort/velocity, and subtle changes in bowling technique due to fatigue may contribute to both enhanced understanding of how bowling workload influences injury (McNamara, Gabbett, Chapman, Naughton & Farhart, 2015). With bowling being such a complex movement in terms of biomechanics as well as the physical implications to perform the action correctly, the risk of injury could be assumed to be high. McNamara et al. (2015) supports this by stating that fast bowling workloads have been linked to increased injury risk. This highlights the importance of players and coaches to train correctly and follow precise conditioning practices in order to reduce the risk of injury. Feros, Young and O'Brien (2014) investigated the relationship between selected physical qualities and bowling speed and found that the 1-RM (repetition maximum) pull-up displayed a large correlation with bowling speed. This suggests that muscles such as the latissimus dorsi, which is heavily involved in the pull-up action, plays an important role in being conditioned to bowl fast.

Other suggestions on important conditioning practices for bowling come from Webster and Roberts (2011), who suggest that bowlers should focus on developing lower-body speed (explosive and repetitive) and anaerobic upper-body power. This coincides with earlier mentioned research which emphasizes the importance of high-intensity efforts for bowling. Greater flexibility around the lower lumbar and hamstrings could be needed within the

bowling group because of the technical movements that occur during the bowling delivery (Webster & Roberts, 2011). A system that can accurately and automatically record bowling counts is a valuable tool for the coach to monitor the workloads of fast bowlers (McNamara et al., 2015). There seems to be insufficient research done on the demands of spin bowling.

2.2.3 Fielding

A cricket field can be divided into two main sections about the pitch – an infield and an outfield (Lockie et al., 2014). A player's position in the field can be influenced by a number of factors such as skill level. Fielders closer to the batsman and have less time to react to balls that are hit hard by batsmen (Bartlett, 2003), whereas outfielders require a strong throwing arm to field the ball back to the infield.

A study by MacDonald et al, (2013) used a time-motion analysis system to define seven movement classes namely stationary, walking, shuffling, jogging, running, low-intensity fielding and high-intensity fielding. It was found that the cover point fielder spends the majority of match time (94.2%) in stationary activity and walking, while high-intensity activities represented just 1.6%of movement activity. However, these results were found to be of limited value as only one fielding position was analyzed. A more in-depth study was done by Petersen et al, (2010) found that when fielding in ODGs players on average covered 10.8 km in their respective innings (210 min). However, the intensity of fielding is dependent on the format with the shorter format requiring greater intensity. It is also important to take into account that majority of the players need to perform the task of fielding. Fielding in cricket will also often require a maximal sprint in pursuit of the ball

after it has been hit by a batsman, and these sprints tend to be over a short distance (Lockie et al., 2014). This indicates the type of conditioning needed for fielders to perform well during competition. Being able to sprint repeatedly and intermittently seems to be an important requirement. State-level Australian cricketers had an average sprint distance of 15 ± 4 m when in the field (Petersen et al., 2010). Information like this can help coaches to set training drills to match competition more closely. However, most research conducted around cricket has focused on the demands of batting and bowling. With fielding being the one discipline in which all 11 players do together, more in-depth knowledge on how to coincide the skill aspect with the physical demands would be advantageous in the future.

2.2.4 Wicket Keeping

In terms of wicket keeping, a review by MacDonald et al. (2013) found that the physical requirements of the wicket keeper are largely decided by the physiological and technical requirements. It was found that for speed, having very good first-step quickness or accelerative ability would be another advantageous quality for a wicket keeper. Petersen et al, (2010) found that although wicket keepers covered a large total distance, they rarely sprinted during fielding innings. This suggests that the physical demands for wicket keeping are low. Furthermore, wicket keepers had enjoyed a considerably longer recovery periods between high-intensity activity than other sub-disciplines. In contrast to this Aughey (2011) found that wicket keepers should not only perform well in their individual discipline but as a batsman as well.

Looking further into research regarding wicket keeping, MacDonald et al. (2013) investigated key movements and skills of wicket keepers and found that 75% of the wicket keepers movement was lateral, either in the form of a shuffle or step. This gives more insight into the type of training that wicket keepers should undergo. Other findings from McDonald et al. (2013) were that the wicket keeper was found to be the fielder most involved in the game, taking 32% of all fielding contacts, as well as having to perform occasional bouts of reactive, explosive, high-intensity efforts such as diving and jumping (on average 5 times per innings). This gives further insight into training and conditioning practices required for wicket keepers to perform optimally. Recommendations what is required from McDonald et al, (2013) are that strength/strength endurance base in tandem with high aerobic fitness would be advantageous for wicket keepers. Reactive agility and change of direction training with pads off and on is recommended (McDonald et al., 2013). The information mentioned could add value to the preparation wicket keepers go through, however, more investigation around what they do during training in comparison to a match is needed.

2.2.5 Training Methods

Low, Williams, McRobert and Ford (2013) investigated the microstructure of practice activities involved in elite and amateur level junior cricketers and found that practice plays an important role in skill acquisition, although not all practice is of equal quality. This implies that training activities might not always be related to what is needed to perform at optimal level physically. Duffield and Drinkwater (2008) found that both test matches and

one-day matches were characterized by mostly low-intensity activity coupled with bouts of high-intensity activity similar to that of repeat-sprint team sports. This suggests that there is a need for high intensity running activities to be included in training for batsmen in cricket although most sessions include batters just batting on one spot in the net area. Another study suggests that there is a gap in research on training for optimal skill acquisition (Low et al., 2013). This indicates a need for further investigation around the physical demands of cricket and how conditioning and skills training related to meet those demands. Cotterill (2011) who documented prep-performance routines in batsmen found that routines developed were beneficial to the successful execution of the cricketing skills of the players. This highlights the impact that quality training has on game performance.

A study conducted by Vickery, Dascombe, Duffield, Kellett and Portus (2013) on the physiological responses and movement demands associated with modified versions of small-sided games for cricket training, found that whilst the physical and physiological demands are considerable and prolonged, historically a greater training emphasis is placed on development of technical abilities rather than physical capacities. Vickery, Dascombe and Scanlan (2018) conducted a study on the physical and physiological demands associated with fast and spin bowling in cricket and found that net-based training does not replicate demands of match-play, which supports evidence from (Vickery et al, 2013). This emphasizes the need to develop concrete, scientific based conditioning programs for the game.

2.2.6 Global Positioning System (GPS)

GPS units, permit reliable and valid measurement of activity responses in cricket (Scanlan et al., 2016). This is supported by Reardon, Tobin and Delahunt (2015) who found that the reliability of the units has previously been demonstrated as acceptable for measuring speed and distances in team sports. In contrast to this, Vickery et al, (2014) found that measures of both reliability and accuracy appear largely reduced when traveling at higher speeds over short distances.

Pote and Christie (2013) investigated how scoring a simulated ODG century would impact batting performance in terms of skill and concentration. This is similar to a study by Houghton, Dawson, Rubenson, and Tobin (2011) that simulated a cricket batting innings to replicate the physical demands of scoring a century during One-Day International cricket using GPS. However, both were conducted in a simulated setting, which cannot with certainty be an accurate reflection of a real game. In support of the validity of GPS units for data collection, Vickery et al. (2014) found evidence to suggest that GPS devices possess an acceptable level of accuracy and reliability when measuring moderate to longer distances whilst running at slow to moderate speeds. Cummins, Orr and O'Connor (2013) conducted a literature review on the use of GPS and micro technology sensors in team sports. They found variables such as speed, distance, sprint distance, and the number of high-intensity efforts at the higher speeds could be determined using this kind of technology. Scanlan et al, (2016) found that most studies adopt the following criteria: standing/walking = ≤2 m/s, jogging = 2.01 to 3.5 m/s, running = 3.51 to 4 m/s, striding = 4.01 to 5 m/s, and sprinting = >5 m/s when using the units.

There are various types of GPS units that measure at different frequencies, namely 5 Hertz (Hz), 10 Hz and 15 Hz. Reardon et al. (2015) found the 10 Hz sampling frequency to be up to six times more reliable at measuring instantaneous velocity than 5 Hz units. This indicates that 10 Hz frequency units are the most reliable. To support this Johnston, Watsford, Kelly, Pine and Spurrs (2014) investigated the validity and inter-unit reliability of 10 Hz and 15 Hz GPS units for assessing athlete movement demands and found that in general, the 10 Hz GPS units measured movement demands with greater validity and inter-unit reliability than the 15 Hz units. Global positioning system (GPS) technology has rapidly advanced in recent years and has become a common method for assessing the physical demands of training and competition in field-based team sports (Rampinini, Alberti, Fiorenza, Riggio, Sassi, Borges & Coutts, 2014).

2.2.7 Conclusion

Based on the literature reviewed, it can be concluded that there is a definite paucity of information regarding the physical demands of cricket, especially during competition, and the extent to which cricket training loads meets the game demands. Furthermore, numerous cricket studies have been conducted in simulated settings with few focusing on the physical effects of cricket during actual competitions.

CHAPTER 3 METHODOLOGY

3.1 Research Design

The study employed a quantitative design as it essentially collected numerical data to describe and analyze the physical demands of ODGs and cricket training sessions preceding these games. The study is descriptive and comparative as it also compares the results for different sub-disciplines within the game, as well as players competing at provincial and university level.

3.2 Research Setting

This study took place at cricket facilities in the Western Cape, South Africa during the middle phase of the cricket season. The university data were collected at a University in the Western Cape and at the Provincial team's club facilities. The provincial data were collected at PPC Newlands Cricket Stadium and Claremont Cricket Club Oval. The testing took place at training sessions (n=6) and one-day matches (n=3) of both the club and provincial teams respectively over a period of 6 weeks.

3.3 Sampling of Subjects

When permission to conduct the research was received, coaches of the University team and the various senior Provincial teams were contacted and sent a permission letter to conduct research, which explained the outline of the study. Following the request to conduct research, the university coach agreed as well as the provincial coach agreeing to allow their respective teams to take part in the study. The sample was purposively selected and

consists of male cricket players that play at senior provincial level cricket, , as well as university cricket players that participate in the local club premier league one-day competition.

Upon meeting with the coaches and players of the respective teams, each was given an information sheet explaining the study and consent form which, if the player agreed to participate was signed. The provincial players consisted of 16 cricketers while the University players consisted of 25 cricketers, giving a sample size of 41 male cricket players. Players were classified into the five areas of play namely batting (n), fast bowling (n), spin bowling (n), fielding (n) and wicket keeping (n) for comparative purposes.

3.4 Inclusion Criteria

Participants included in the study were: male cricket players from a university in the Western Cape who participates in the local one day club cricket competition and male cricket players that play in the senior provincial teams who gave informed and written consent; players who were most likely to play following the training sessions leading up to a match were also chosen ahead of those who were not to be part of the study.

3.5 Exclusion Criteria

Participants excluded from the study were: those who were injured; University players who did not play in the Club One Day competition; Provincial players who did not play in the CSA Provincial One-Day Challenge; those who were not staying at training for the entire duration of the session.

3.6 Research Procedure

For each team, data were gathered from players during training sessions (n=2) leading up to a game, as well as during the game of that specific week (n=1). The data were then categorized into the four disciplines or areas of play namely batting, bowling, fielding, and wicket keeping. Furthermore, bowling was separated into fast bowlers and spin bowlers for comparative purposes.

Data for provincial players were gathered and recorded during official provincial ODGs (n=3) while university student data was gathered and recorded during formal league ODGs (n=3).

GPS Units and heart rate monitors were used to assess the physical demands on players during training sessions and ODGs. The GPS units and heart rate monitors were attached to players for the duration of a match as well as during training sessions. The GPS unit was switched on at the commencement of activity and switched off at the end of activity, this was done to the best of the researcher's ability in order to avoid readings of inactivity outside the field of play affecting the training and game data. Warm ups and cool down were not included in the data collection. The units tracked movements of players by means of satellites and radio transmitters.

The GPS system allows real-time data and record performance on a movement tracking system. This data that was stored onto the GPS device was then downloaded onto a computer for analysis after each training session and match. This study describes the differences in intensity, of workload and performance, between training sessions observed

during the week leading up to a match, as well as the actual match. The GPS units are designed to record time-motion analysis effectively (i.e. changes in distance, speed, and even workload).

The variables which were used in the study are time/duration of the session, total distance travelled (including walking [0.3 – 6.0km/h] + jogging [6.9 – 12.6km/h] + running [12.6 – 14.7km/h] + striding [14.7 – 18km/h] + sprinting [18 – 30km/h]), total number of sprints, average sprint distance, maximum heart rate, average heart rate and average heart rate zone. Once the data was downloaded, it was categorized into these variables for statistical analysis.

The format of procedures followed is briefly indicated below:

Step 1: Sampling of Subjects – obtaining consent

Step 2: Fitting players with GPS units and heart rate monitors before training sessions and monitoring the activity of each player during training in order to place them in sub-discipline groups.

Step 3: Downloading information gathered from training sessions.

Step 4: Fitting players with GPS units and heart rate monitors before games and monitoring player activity during the games in order to place them in sub-discipline groups.

Step 5: Downloading information gathered from the game.

3.7 Research Instrument

GPS (Workload and Performance Measures)

The participants were fitted with a GPS unit (GPSports, MinimaxX v2.0, 10Hz sampling rate) and a heart rate monitor (Polar T34 Heart Rate Transmitters) for the duration of the training sessions and matches. The GPS unit was strapped to a vest that the players can wear over or under their gear. The unit sits inside a pouch on the back of the vest, located between the shoulder blades. The GPS unit is able to measure; maximum speed, average speed, distance traveled, position, altitude, maximum heart rate and average heart rate (with the data transmitted by the heart rate monitors). Heart rate monitors were placed around the player's chest area underneath the vest and transmitted heart rate data to the GPS unit via wireless sensors. The units are splash proof, weigh 110g and have a rechargeable Li-ion battery. The unit is capable of storing up to four hours of recorded data and comes with a GPS Sports Analysis System. All the data was collected from the GPS software. Figure 1.1 below displays an example of the GPS unit and heart rate monitor on a participant.

Figure 1: GPS unit and Heart Rate Monitor on a participant.

3.8 Statistical Analysis

GPS data was downloaded onto a computer and converted for analysis purposes. Statistical analysis was conducted using IBM SPSS statistics software V23. Data were presented as means and standard deviations. An independent samples t-test was used to assess whether there are differences between the physical exertion during training and a game. A one-way ANOVA was conducted to test for differences between sub-disciplines (batsmen, fast bowlers, spin bowlers, fielders, and wicket keepers) in terms of their training loads and match loads. A post-hoc Tukey test was done to establish which means were significantly different from each other. The level of significance was set at $p<0.05$.

CHAPTER 4

RESULTS

4.1 Introduction

The aim of this study is to assess and compare physical demands of a ODG and cricket training sessions for both provincial and university cricket players across the different playing positions. The results, which emanated from this descriptive and comparative study, are presented in this chapter.

4.2 Movement Patterns of University Cricket Players

Table 1 is a summary statement of the distances covered by university cricket players in the different movement categories (walking, jogging, etc.) in their respective playing positions as well as the total distance covered during a regular training session. The bowlers (spin and fast) covered the greatest distances during the training sessions. The bulk of the motion involved walking and jogging to a lesser extent. Table 2 depicts the same movement breakdown during a ODG for University cricket players. It is evident from Table 2 that the cricket players covered long distances during a ODG, ranging from 1,68km for batsmen to 8.21km for fast bowlers. Fast bowlers also covered the greatest distances in striding and sprinting compared to all the other playing positions. This is true for both the training sessions and the game situation. Fast bowlers from the university team sprinted as much as 1,1km during the ODG compared to the 133m sprint distance covered by spin bowlers.

Table 1: Mean Distances (SD) covered by university cricket players during a training session per playing position and per movement category

Variable	Total Distance (m)	Walking (m)	Jogging (m)	Running (m)	Striding (m)	Sprinting (m)
Batsmen	840(151)	654(143)	178(92)	5.7 (9)	0.7 (2)	0.8 (3)
Fast Bowlers	2699(882)	1608 (459.7)	434 (279)	119 (87)	215(105)	312 (249)
Spin Bowlers	2240 (1263)	1587 (862)	542 (371)	74 (125)	39.6 (68)	7(13)
Fielders	966 (283)	654(194)	190(79)	39 (40.5)	55.3 (69)	29 (26)
Wicket Keepers	1770.4	1636.7	132.4	0	0	0

Table 2: Mean Distances (SD) covered by university cricket players during a ODG per playing position and per movement category.

Variable	Total Distance (m)	Walking (m)	Jogging (m)	Running (m)	Striding (m)	Sprinting (m)
Batsmen	1677 (1751)	1153(1220)	169 (181)	75 (85)	136 (161)	135(150)
Fast Bowlers	8208.9 (3360)	5652 (440)	912 (429)	220(103)	322 (138)	1099 (495)
Spin Bowlers	7107 (2524)	5151(1609)	1488 (497)	209(197)	122 (133)	133 (86)
Fielders	5784 (1252)	4450 (1092)	927 (374)	160(99)	114(48)	100 (62)
Wicket Keepers	3658 (1232)	2823 (910)	712 (287)	80(97)	49 (51)	17 (23)

University wicket keepers covered similar total distances at training (1.77km x2) and during the ODG (3.65km). The bulk of the total distance covered consisted of walking during both the training sessions and the game.

4.3. Comparison of Movement Patterns of University Cricketers across Playing Positions during a Training Session and a ODG.

Significant differences were found across all playing positions and movement categories during training sessions (Table 3). The spin bowlers and fast bowlers covered greater total, walking and jogging distances compared to fielders and batters during training sessions ($p<.05$) (Table 3). Fast bowlers covered the greatest striding and sprinting distances ($p<.05$).

Table 3: Comparison of distances covered by university batsmen (Bat), fast bowlers (FB), spin bowlers (SB) and fielders (F) during a training session.

Variable	Batsmen Mean	Fast Bowlers Mean	Spin Bowlers Mean	Fielders Mean	F – Value	pvalue
Total Distance (m)	**840.5**$^{FB, SB}$	**2699.1**$^{Bat, F}$	**2240.6**$^{Bat, F}$	**966.7**$^{FB, SB}$	**23.820**	**0.000***
Walking (m)	**654.2**$^{FB, SB}$	**1608.5**$^{Bat, F}$	**1587.8**$^{Bat, F}$	**654.8**$^{FB, SB}$	**19.675**	**0.000***
Jogging (m)	**178.1**$^{FB, SB}$	**434.8**$^{Bat, F}$	**542.1**$^{Bat, F}$	**190.7**$^{FB, SB}$	**8.328**	**0.000***
Running (m)	**5.7**^{FB}	**119**$^{Bat, F}$	74.8	**39.3**^{FB}	**7.179**	**0.000***
Striding (m)	**0.7**^{FB}	**215.2**$^{Bat, SB, F}$	**39.6**^{FB}	**55.3**^{F}	**27.470**	**0.000***
Sprinting (m)	**0.8**^{FB}	**312**$^{Bat, SB, F}$	**7.2**^{FB}	**29.7**^{FB}	**18.861**	**0.000***

*. The mean difference is significant at the 0.05 level
Superscripts identifying differing groups

Batters differed significantly from all other playing positions in terms of the total, walking and jogging distances covered during a ODG (Table 4). Fast bowlers covered the greatest sprinting distances and, except for spin bowlers, also all the striding distances.

Table 4: Comparison of distances covered by university batsmen (Bat), fast bowlers (FB), spin bowlers (SB) Fielders (F) and wicket keepers (W) during a ODG.

Variable	Batsmen Mean	Fast Bowlers Mean	Spin Bowlers Mean	Fielders Mean	Wicket Keeper Mean	F – Value	p-value
Total Distance (m)	**1677** $^{FB, SB, F, WK}$	**8209** $^{Bat, WK}$	**7107.1**^{Bat}	**5784.7**^{Bat}	**3658.4**^{FB}	**15.056**	**0.000***
Walking (m)	**1153** $^{FB, SB, F, WK}$	**5651.89**$^{Bat, WK}$	**5151.8**^{Bat}	**4450.3**^{Bat}	**2823.2**^{FB}	**14.771**	**0.000***
Jogging (m)	**169** $^{FB, SB, F, WK}$	**912.9**^{Bat}	**1488.5**^{Bat}	**927.9**^{Bat}	**712.7**$^{Bat, SB}$	**15.394**	**0.000***
Running (m)	**75.6** ^{FB}	**220.5**^{Bat}	209.9	160.4	80.8	**3.237**	**0.024***
Striding (m)	**136.7** ^{FB}	**322.6**$^{Bat, F, WK}$	122.8	**114.3**^{FB}	**49.3**^{FB}	**3.731**	**0.013***
Sprinting (m)	**135.4** ^{FB}	**1100**$^{Bat, SB, F, WK}$	**133.4**^{FB}	**100.8**^{FB}	**17**^{FB}	**25.068**	**0.000***

*. The mean difference is significant at the 0.05 level
Superscripts identifying differing groups

4.4. Movement Patterns of University Students during a Training Session Compared to ODGs.

Tables 5 to 8 depict the distances covered by university cricket players in various movement categories (walking, jogging, etc.), at training in comparison to a ODG

The mean distances for all movement patterns were greater during a ODG in comparison to a training session except for jogging (Table 5). There were significant differences for all movement patterns for batters between a ODGs and training session except for walking and jogging.

Table 5: Comparison of distances covered by university cricket batters during a training session and ODG.

Variable	Training Mean	Game Mean	F-value	p-value
Total Distance (m)	**840.5**	**1677.1**	**4.327**	**0.046***
Walking (m)	654.2	1153.3	3.148	0.086
Jogging (m)	178.1	169.8	0.030	0.864
Running (m)	**5.7**	**75.6**	**12.741**	**0.001***
Striding (m)	**0.7**	**136.7**	**13.585**	**0.001***
Sprinting (m)	**0.8**	**135.4**	**15.306**	**0.000***

*P< 0.05 level

All movement patterns for fast bowlers differed significantly between training and ODGs except for striding (Table 6). Fast bowlers covered much greater distances during a match in comparison to training for each movement pattern.

Table 6: Comparison of distances covered by University cricket fast bowlers during a training session and ODG.

Variable	Training Mean	Game Mean	F-value	p-value
Total Distance (m)	**2699.1**	**8208.8**	**32.206**	**0.000***
Walking (m)	**1608.5**	**5651.8**	**35.322**	**0.000***
Jogging (m)	**434.8**	**912.9**	**8.595**	**0.009***
Running (m)	**119**	**220.5**	**4.985**	**0.039***
Striding (m)	215.2	322.6	3.518	0.078
Sprinting (m)	**312**	**1099.8**	**21.907**	**0.000***

*. The mean difference is significant at the 0.05 level

All movement patterns except running and striding were significantly different to one another for spin bowlers between training and ODGs (table 7). Distances covered during games were greater than during training for all movement patterns.

Table 7: Comparison of University cricket spin bowlers during a training session and ODG.

Variable	Training Mean	Game Mean	F-value	p-value
Total Distance (m)	**1587.8**	**5151.8**	**18.216**	**0.002***
Walking (m)	**542.1**	**1488.5**	**21.919**	**0.001***
Jogging (m)	**542.1**	**1488.5**	**9.747**	**0.012***
Running (m)	74.8	209.9	1.632	0.233
Striding (m)	39.6	122.8	1.849	0.207
Sprinting (m)	**7.2**	**133.4**	**26.121**	**0.001***

*. The mean difference is significant at the 0.05 level

All movement patterns were significantly different between training and ODGs for fielders (Table 8). Fielders covered greater distances during a ODG in comparison to training for all movement categories.

Table 8: Comparison of distances covered by university cricket fielders during a training session and ODG.

Variable	Mean Training	Mean Game	F-value	p-value
Total Distance (m)	**966.7**	**5784.7**	**154.884**	**0.000***
Walking (m)	**654.8**	**4450.3**	**128.888**	**0.000***
Jogging (m)	**190.7**	**927.9**	**40.767**	**0.000***
Running (m)	**39.3**	**160.4**	**14.028**	**0.001***
Striding (m)	**55.3**	**114.3**	**5.048**	**0.037***
Sprinting (m)	**29.7**	**100.8**	**11.934**	**0.003***

*. The mean difference is significant at the 0.05 level

4.5 Movement Variables and Physiological Responses of University Players during a Training Session Compared to a ODG.

4.5.1 Comparison of Movement Variables for University Players

Figures 2 and 3 are a summary of the amount of sprints university cricket players did at training in comparison to a ODG per playing position, as well as the average distance per sprint.

The number of sprints had significant differences for all playing positions ($p<0.05$) except fielders ($p=0.069$) between training and a match (Figure 2). All playing positions did a greater amount of sprints during a match in comparison to training. Fast bowlers did the highest number of sprints during training (11.1) and a game (30.5). Batsmen (0) and spin

bowlers (0) did the lowest amount of sprints at training while fielders (8.1) did the lowest during a match

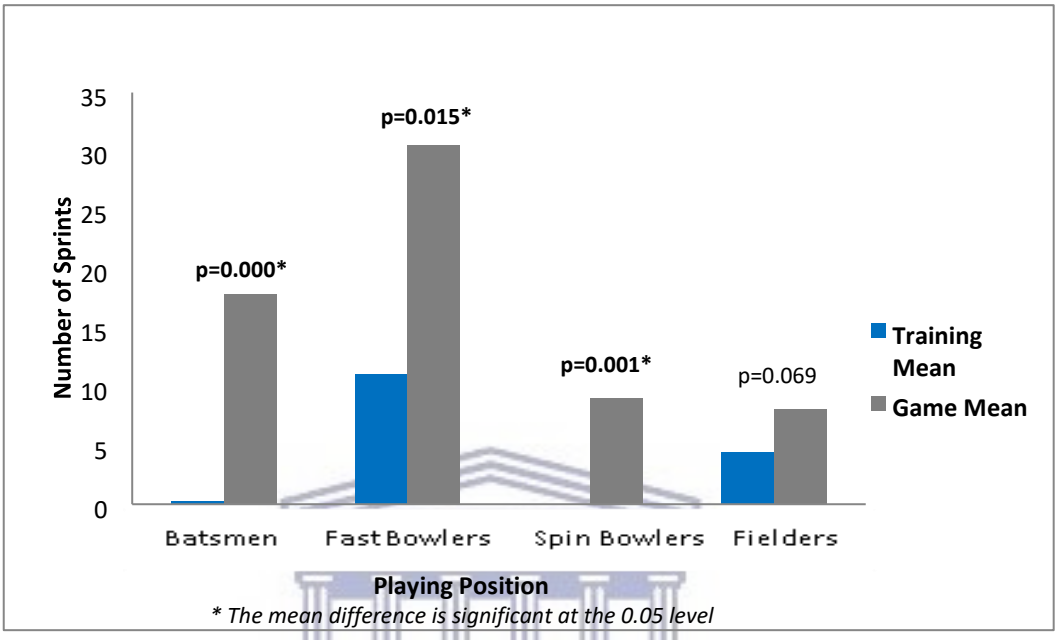

Figure 2: Number of sprints per playing position during training and a ODG (university players).

The average sprint distance was significantly different ($p<.05$) for all playing positions between training and the ODG (Figure 3). All playing positions covered a greater distance per sprint event during a ODG in comparison to training. Fast bowlers covered the greatest average distance per sprint during training (12.1m) and the ODG (22.1m). Spin bowlers covered the lowest average distance per sprint at training (0m) while batsmen covered the lowest average distance per sprint during a match (12.4m).

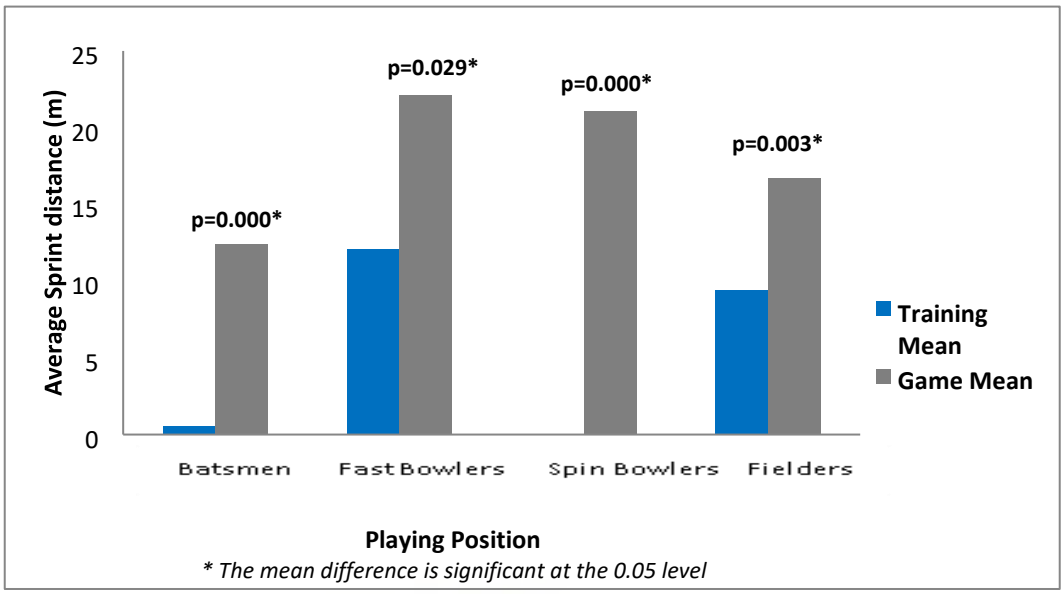

Figure 3: Average sprint distance covered per playing position during training and a ODG

(University players)

4.5.2 Comparison of Physiological Responses for University Players

Figures 4 and 5 depict the average heart rates university cricket players reached during a training session compared to a ODGs per playing position as well as the maximum heart rate reached per playing position.

The results show significant difference for the average heart rate of batsmen (p=0.019) only between training and a game (Figure 4). Each playing position had a higher average heart rate during a game in comparison to training except for fielders. Fast bowlers had the highest average heart rates at training (143.5bpm) and during a game (154.2bpm) while fielders had the lowest average heart rates at training (121.3bpm) and during a game (119.3bpm).

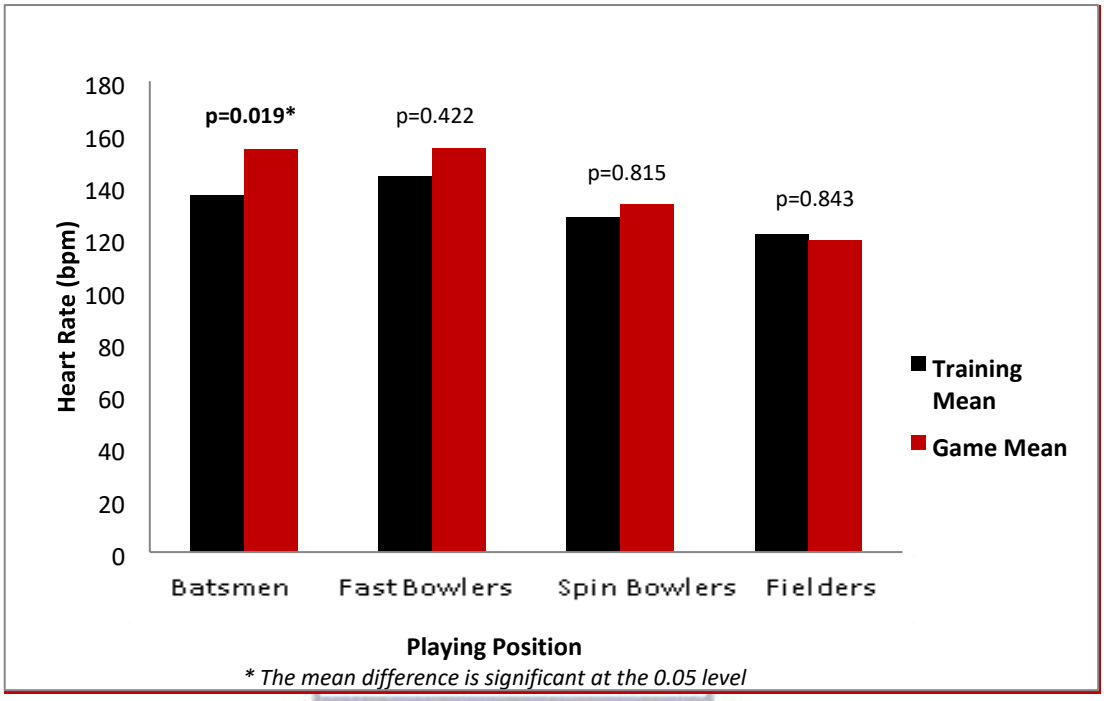

Figure 4: Average heart rate per playing position during training and game situation (University players)

There were significant differences ($p<0.05$) between training and a ODGs for the maximum heart rates reached of batsmen ($p=0.040$) and fielders ($p=0.007$) only (figure 5). All playing positions reached higher maximum heart rates during a game in comparison to training except spin bowlers who had a higher maximum heart rate during training. Fast bowlers had the highest maximum heart rates for training (182.2bpm) and a game (199.2bpm) of all playing positions.

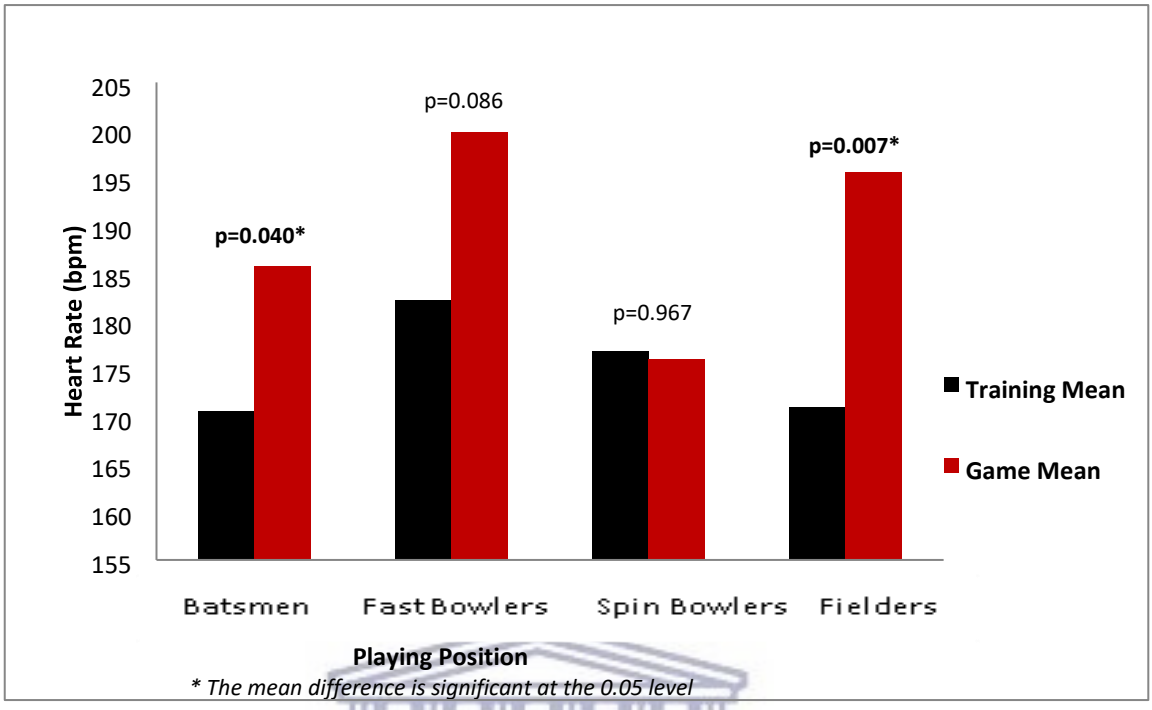

Figure 5: Maximum heart rate per playing position during training and a ODG (University players)

4.6 Movement Patterns of Provincial Cricket Players

The movement patterns of provincial players during a training and a game session are given in Tables 9 and 10. The provincial players had a similar movement pattern to those of university students with fast bowlers covering a total distance of 2,41km during training and 8,79km during the ODG (Tables 9 and 10). The lowest distances were recorded for batsmen with 0,75km (training) and 1,31km (game) covered respectively. Most of the players, for both the university and the provincial teams, regardless of their playing positions, spent most of their time walking on the field. Fast bowlers spent 60% of their time on the field on walking compared to 93% for wicketkeepers.

Table 9: Mean Distances (SD) covered by provincial cricket players during a training session per playing position and per movement category

Variable	Total Distance (m)	Walking (m)	Jogging (m)	Running (m)	Striding (m)	Sprinting (m)
Batsmen	751 (116)	611 (131)	131 (106)	8(19)	0.4(1)	0
Fast Bowlers	2409 (432)	1371 (259)	225 (15)	76(18)	143(54)	557 (184)
Spin Bowlers	2423 (697)	1847 (640)	526 (141)	26(35)	14 (24)	9 (17.9)
Fielders	1308 (560)	702 (135)	395 (396)	65(75)	120(190)	26 (116)

Table 10: Mean distances (SD) covered by provincial cricket players during a ODG per playing position and per movement category

Variable	Total Distance (m)	Walking (m)	Jogging (m)	Running (m)	Striding (m)	Sprinting (m)
Batsmen	1677 (1751	1153(1220)	169(181)	75.6± 85	137(162)	135(150)
Fast Bowlers	8209(3360)	5652(2439)	912 (429)	221(103)	323 (138)	1100 (495)
Spin Bowlers	7107(2524)	5151 (1609)	1488 (497)	210(197)	123 (133)	133 (87)
Fielders	5784 (1252)	4450 (1092)	927.9(374)	160(98)	114 (47)	101 (62)
Wicket Keepers	3658(1232)	2823 (910)	712.7 (287)	81 (97)	49.3 ±50.5	17 (23)

4.7 Comparison of Movement Patterns of Provincial Cricketers across Playing Positions during a Training Session and a ODG

Significant differences were found across all playing positions and movement categories during training sessions except for striding (Table 11). Provincial fast bowlers covered the greatest distances for all movement categories except jogging in comparison to other playing positions and differed significantly from batsmen, in all movement categories except striding for which no significant differences were observed across all playing positions ($p<.05$). Fast bowlers also differed significantly from spin bowlers for sprinting and fielders for walking. Provincial spin bowlers differed significantly from batsmen (for walking and jogging), fast bowlers (sprinting) and fielders (walking). No significant differences were observed for running. Provincial fielders differed significantly from fast bowlers (for walking and sprinting) and spin bowlers (for walking) ($p<.05$).

Table 11: Comparison of distances covered by Provincial batsmen (Bat), fast bowlers (FB), spin bowlers (SB) and fielders (F) during a training session

Variable	Batsmen Mean	Fast Bowlers Mean	Spin Bowlers Mean	Fielders Mean	F – Value	p-value
Total Distance (m)	**751.1$^{FB, SB}$**	**2409.1$^{Bat, F}$**	**2423.7$^{Bat, F}$**	**1308.9$^{FB, SB}$**	**17.823**	**0.000***
Walking (m)	**611.2$^{FB, SB}$**	**1371.1$^{Bat, F}$**	**1847.8$^{Bat, F}$**	**702.1$^{FB, SB}$**	**14.809**	**0.000***
Jogging (m)	**131.5^{SB}**	**225.2^{Bat}**	**526.6^{Bat}**	395.1	**4.017**	**0.026***
Running (m)	**7.7^{FB}**	**75.5^{Bat}**	25.6	65.3	3.714	**0.034***
Striding (m)	0.4	143.9	14.3	120.5	3.588	**0.037***
Sprinting (m)	**0^{FB}**	**557.1$^{Bat, SB, F}$**	**9.3^{FB}**	**26.1^{FB}**	**39.236**	**0.000***

*. The mean difference is significant at the 0.05 level
Superscripts identifying differing groups

4.8 Movement Patterns of Provincial Players per Playing Position during a Training Session Compared to a ODG

Tables 12 to 15 give a summary statement of distances covered by provincial cricket players in various movement categories (walking, jogging, etc.), at training in comparison to a ODGs.

Distances for all movement patterns were greater during a game in comparison to training for provincial batsmen (table 12). There were significant differences between training and a game for running, striding and sprinting.

Table 12: Comparison of provincial cricket batters during training and a ODG.

Variable	Training Mean	Game Mean	F-value	p-value
Total Distance (m)	751.1	1306.5	1.866	0.195
Walking (m)	611.2	813.5	0.691	0.421
Jogging (m)	131.5	148	0.083	0.778
Running (m)	**7.7**	**68.6**	**6.848**	**0.021***
Striding (m)	**0.4**	**128.9**	**8.538**	**0.012***
Sprinting (m)	**0**	**149.4**	**5.776**	**0.032***

*. The mean difference is significant at the 0.05 level

Provincial fast bowlers showed significant differences for all movement patterns except sprinting between training and games (Table 13). Distances were greater during games in comparison to training sessions for all movement patterns.

Table 13: Comparison of provincial cricket fast bowlers during training and a ODG.

Variable	Training Mean	Game Mean	F-value	p-value
Total Distance (m)	**2409.1**	**8790.3**	**16.741**	**0.003***
Walking (m)	**1371.1**	**6234.6**	**17.248**	**0.002***
Jogging (m)	**225.2**	**1347.4**	**16.442**	**0.003***
Running (m)	**75.5**	**234.7**	**9.824**	**0012***
Striding (m)	**143.9**	**291.1**	**6.208**	**0.034***
Sprinting (m)	557.1	674.1	1.256	0.291

*. The mean difference is significant at the 0.05 level

Spin bowlers showed significant differences between training and games for running and striding patterns (Table 14). All distances covered during training were less in comparison to a match.

Table 14: Comparison of provincial cricket spin bowlers between training and a ODG.

Variable	Training Mean	Game Mean	F-value	p-value
Total Distance (m)	2423.7	4353.8	2.100	0.221
Walking (m)	1847.8	3025.4	1.454	0.294
Jogging (m)	526.6	1083.9	2.359	0.199
Running (m)	**25.6**	**143.3**	**12.633**	**0.024***
Striding (m)	**14.3**	**74.7**	**10.629**	**0.031***
Sprinting (m)	9.3	25.8	0.783	0.426

*. The mean difference is significant at the 0.05 level

Provincial cricket fielders covered greater distances during a game for all movement patterns except striding (table 15). There were significant differences for total distance, walking and sprinting for fielders between training sessions and games.

Table 15: Comparison of Provincial cricket fielders between training and a ODG.

Variable	Mean Training	Mean Game	F-value	p-value
Total Distance (m)	**1308.9**	**5657.9**	**17.417**	**0.004***
Walking (m)	**702.1**	**4416.8**	**38.937**	**0.000***
Jogging (m)	395.1	871.2	2.067	0.194
Running (m)	65.3	136.6	0.531	0.490
Striding (m)	120.5	117.2	0.001	0.977
Sprinting (m)	**26.1**	**111.1**	**7.996**	**0.025***

* The mean difference is significant at the 0.05 level

4.9 Movement Variables and Physiological Responses of Provincial Players during a Training Session Compared to a ODG.

4.9.1 Comparison of Movement Variables for Provincial Players

Figures 6 and 7 summarize the number of sprints provincial cricket players did at training in comparison to a ODGs per playing position, as well as the average distance per sprint.

The number of sprints had significant differences for batsmen (p=0.020) and fast bowlers (p=0.020) only between training and a match (Figure 6). All playing positions did a higher

number of sprints during a match in comparison to training. Batsmen (0) and fielders (0) did the lowest amount of sprints at training in comparison to fast bowlers (14.3) who did the highest. During a match, spin bowlers did the lowest number of sprints (0) in comparison to batsmen (19.4) who did the most.

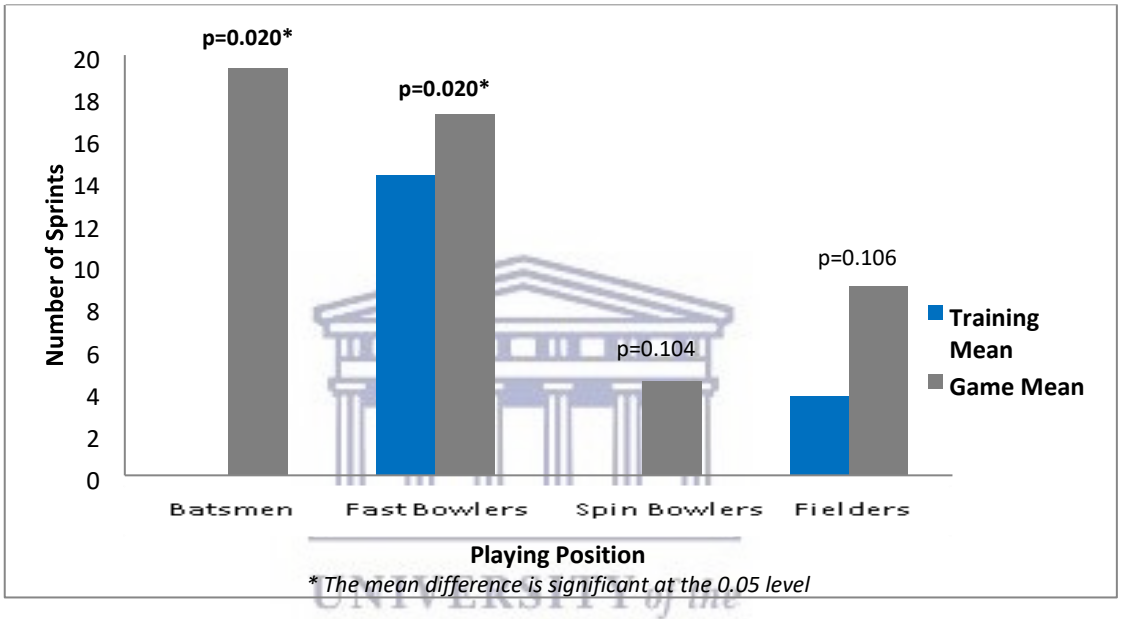

Figure 6: Number of sprints per playing position during training and the ODG (Provincial players).

The average sprint distance had significant differences for all playing positions ($p<0.05$) except fielders ($p=0.106$) (Figure 7). All playing positions except provincial fast bowlers covered a greater average sprint distance during a match in comparison to training. Batsmen (0m) and spin bowlers (0m) covered the least average distance per sprint at training while fast bowlers (23.4m) covered the greatest average distance per sprint. Spin bowlers (9.2m) covered the least average sprint distance during a match while fast bowlers (17.2m) covered the greatest average sprint distance.

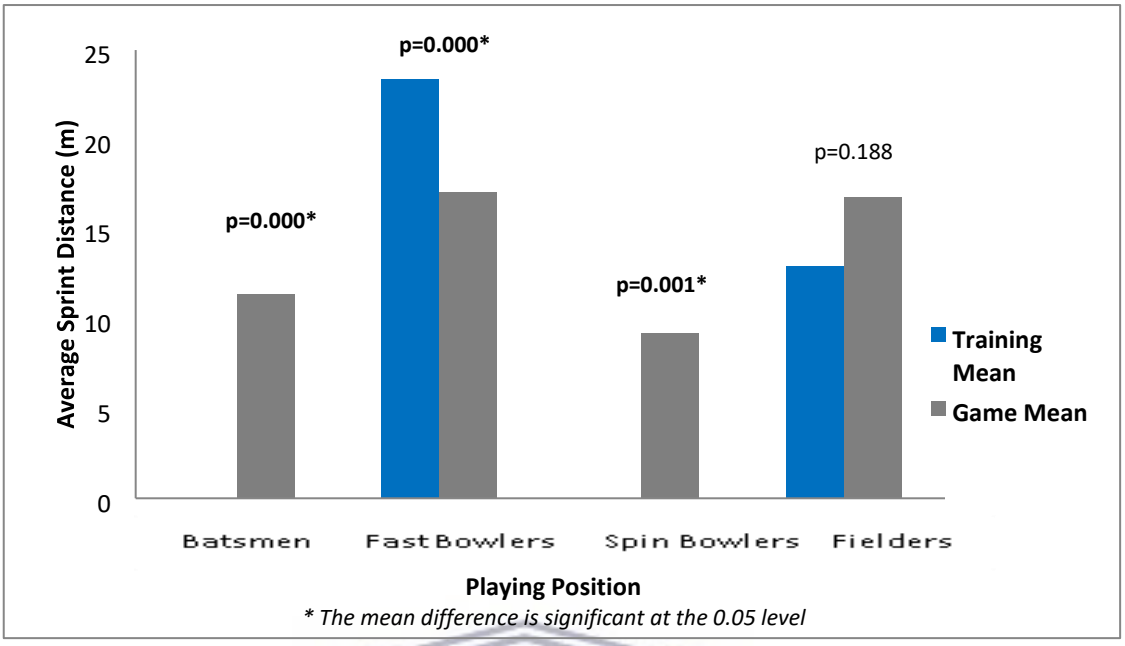

Figure 7: Number of sprints per playing position during training and a ODG (Provincial players).

4.9.2 Comparison of Physiological Responses for Provincial Players

Figures 8 and 9 are a summary statement of the average heart rates provincial cricket players reached during training sessions compared to a ODGs per playing position as well the maximum heart rate reached per playing position.

Provincial batsmen (p=0.009) and fast bowlers (p=0.009) were significantly different from one another between training and a game (Figure 8). Higher average heart rates were reached for all playing positions during a game in comparison to training. Provincial spin bowlers reached the highest average heart rates during training (142.8bpm) and a game (159.5bpm) while provincial fielders reached the lowest average heart rates (training 120.5bpm; game 132.6bpm).

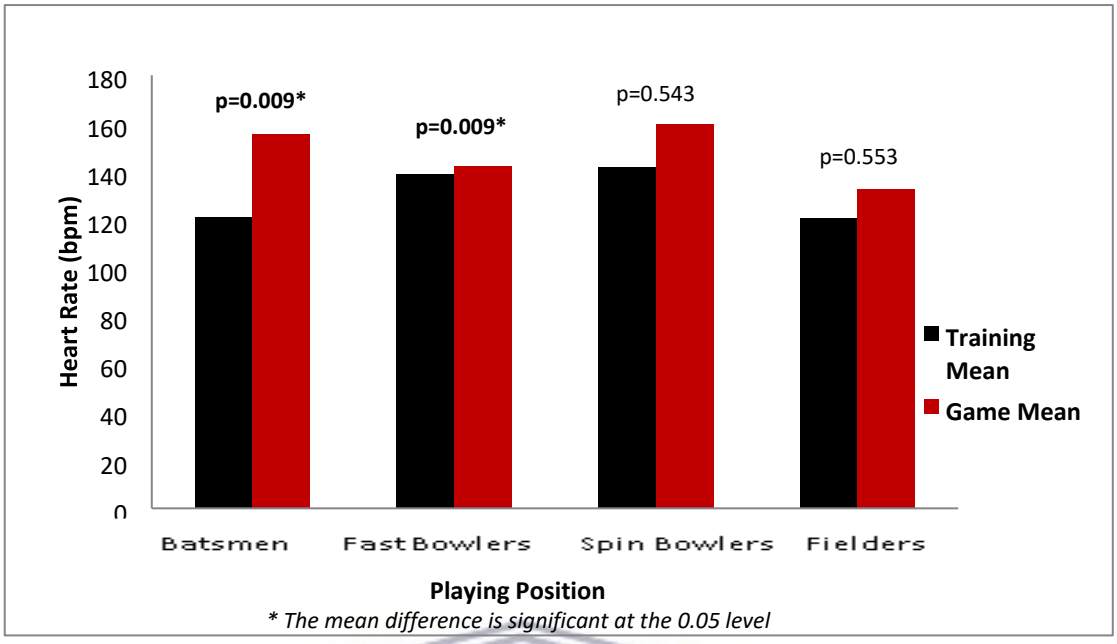

Figure 8: Average heart rate per playing position during training and game situation (Provincial players)

Provincial fielders were significantly different (p=0.050) between training and a game for the maximum heart rates reached (Figure 9). All playing positions reached higher maximum heart rates during a game in comparison to training. Provincial spin bowlers had the highest maximum heart rate during training (172.8bpm) and a game (199.5bpm) of all playing positions.

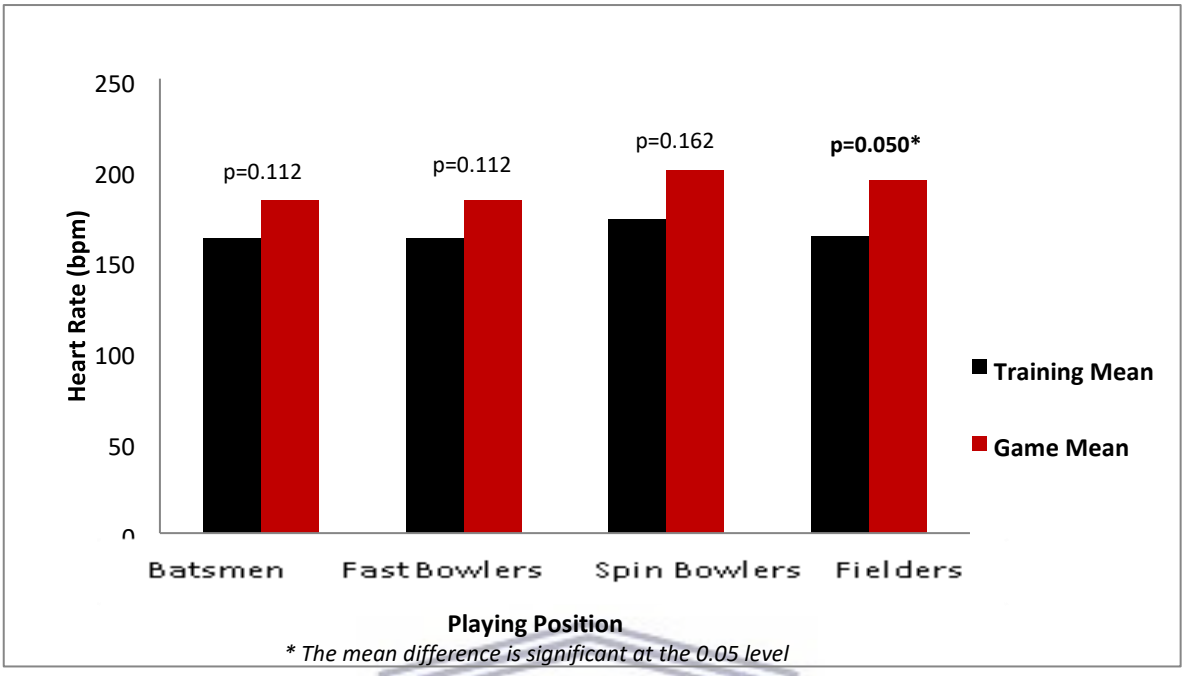

Figure 9: Maximum heart rate per playing position during training and game situation (Provincial players)

4.10 Comparison of the Movement Patterns between University and Provincial Cricketers

4.10.1 Comparison of Movement Patterns during Training

The movement patterns of university and provincial cricketers for the different playing positions are depicted in Tables 16– 19. Table 16 shows the comparative statistics for batters during training. There were no significant differences found between university and provincial batters at training.

Table 16: Comparison of the movement patterns of university and provincial batters at training

Variable	University Mean	Provincial Mean	F - value	p-value
Total Distance (m)	840.5	751.1	1.740	0.200
Walking (m)	654.2	611.2	0.422	0.523
Jogging (m)	178.1	131.5	1.080	0.309
Running (m)	5.7	7.7	0.118	0.734
Striding (m)	0.7	0.4	0.075	0.787
Sprinting (m)	0.8	0	0.307	0.585

*. The mean difference is significant at the 0.05 level

The sprinting distances covered by provincial and university fast bowlers at training differed significantly (Table 17). None of the other movement categories differed significantly.

Table 17: Comparison of the movement patterns of university and provincial fast bowlers at training.

Variable	University Mean	Provincial Mean	F - value	p - value
Total Distance (m)	2699.1	2409.1	0.571	0.460
Walking (m)	1608.5	1371.1	1.369	0.258
Jogging (m)	434.8	225.2	3.281	0.088
Running (m)	119	75.5	1.424	0.249
Striding (m)	215.2	143.9	2.399	0.140
Sprinting (m)	**312**	**557.1**	**4.568**	**0.047***

*. The mean difference is significant at the 0.05 level

There were no significant differences between provincial and university spin bowlers at training in any of the movement categories (Table 18).

Table 18: Comparison of the movement patterns of university and provincial spin bowlers at training

Variable	University Mean	Provincial Mean	F - value	p-value
Total Distance (m)	2240.6	2423.7	0.072	0.793
Walking (m)	1587.8	1847.8	0.287	0.603
Jogging (m)	542.1	526.6	0.006	0.938
Running (m)	74.8	25.6	0.570	0.466
Striding (m)	39.6	14.3	0.498	0.495
Sprinting (m)	0.2	9.3	0.056	0.817

*The mean difference is significant at the 0.05 level

No significant differences were found between provincial and university fielders in any of the movement categories at training (Table 19).

Table 19: Comparison of the movement patterns of university and provincial fielders at training.

Variable	University Mean	Provincial Mean	F - value	p - value
Total Distance (m)	966.7	1309	2.559	0.134
Walking (m)	654.8	702.1	0.197	0.664
Jogging (m)	190.7	395.1	2.981	0.108
Running (m)	39.318	65.3	0.764	0.398
Striding (m)	55.3	120.5	1.031	0.328
Sprinting (m)	29.7	26.1	0.064	0.804

*. The mean difference is significant at the 0.05 level

4.10.2 Comparison of Movement Patterns during a ODGs

The movement patterns of university and provincial cricketers for the different playing positions are depicted in Tables 20 – 23. Table 20 shows the comparative statistics for batters during a ODGs.

There were no significant differences were found between provincial and university batters during a ODGs (table 20). University batters covered greater distances for all movement categories except sprinting

Table 20: Comparison of the movement patterns of university and provincial batters during a ODG

Variable	University Mean	Provincial Mean	F - value	p-value
Total Distance (m)	1677.1	1306.5	0.336	0.568
Walking (m)	1153.3	813.5	0.607	0.444
Jogging (m)	169.8	148	0.106	0.748
Running (m)	75.6	68.6	.049	0.827
Striding (m)	136.7	128.9	.016	0.899
Sprinting (m)	135.4	149.4	.048	0.828

*. The mean difference is significant at the 0.05 level

No significant differences were found between provincial and university fast bowlers during a ODGs (table 21). Provincial fast bowlers covered greater distances for all movement categories except striding and sprinting.

Table 21: Comparison of movement patterns of university and provincial fast bowlers during a ODG

Variable	University Mean	Provincial Mean	F - value	p-value
Total Distance (m)	8208.9	8790.3	0.072	0.794
Walking (m)	5651.8	6234.6	0.132	0.725
Jogging (m)	912.9	1347.4	1.654	0.230
Running (m)	220.5	234.7	.043	0.840
Striding (m)	322.6	291.1	0.147	0.710
Sprinting (m)	1099.8	674.1	3.354	0.100

*. The mean difference is significant at the 0.05 level

No significant differences were found between provincial and university spin bowlers during a ODG (Table 22). University spin bowlers covered greater distances in all movement categories in comparison to provincial spin bowlers.

Table 22: Comparison of movement patterns of university and provincial spin bowlers during a ODG

Variable	University Mean	Provincial Mean	F - value	p-value
Total Distance (m)	7107.1	4353.8	1.049	0.413
Walking (m)	5151.8	3025.4	1.403	0.358
Jogging (m)	1488.5	1083.9	0.368	0.606
Running (m)	209.9	143.3	0.216	0.688
Striding (m)	122.8	74.7	0.261	0.660
Sprinting (m)	133.4	25.8	2.771	0.238

* The mean difference is significant at the 0.05 level

No significant differences were found between provincial and university fielders during a ODGs (Table 23). University fielders covered greater distances in all movement categories except striding and sprinting.

Table 23: Comparison of movement patterns of university and provincial fielders during a ODG.

Variable	University Mean	Provincial Mean	F - value	p - value
Total Distance (m)	5784.7	5657.9	0.023	0.881
Walking (m)	4450.3	4416.8	0.003	0.957
Jogging (m)	927.9	871.2	0.056	0.817
Running (m)	160.4	136.6	0.111	0.744
Striding (m)	114.3	117.2	0.004	0.951
Sprinting (m)	100.8	111.1	0.095	0.762

* The mean difference is significant at the 0.05 level

4.11 Comparison of the Movement Variables and Physiological Responses between University and Provincial Cricketers

4.11.1 Comparison of Movement Variables for University and Provincial Players at Training

Figures 10 and 11 are a summary statement of the amount of sprints university cricket players and provincial cricket players do at training sessions per playing position as well as the average distance per sprint per playing position.

University and provincial players had no significant differences (p>0.05) for all playing positions at training (Figure 10). Provincial fast bowlers (14.1) did the highest number of sprints with provincial batsmen (0), provincial (0), and university spin bowlers (0) doing the lowest amount of sprints.

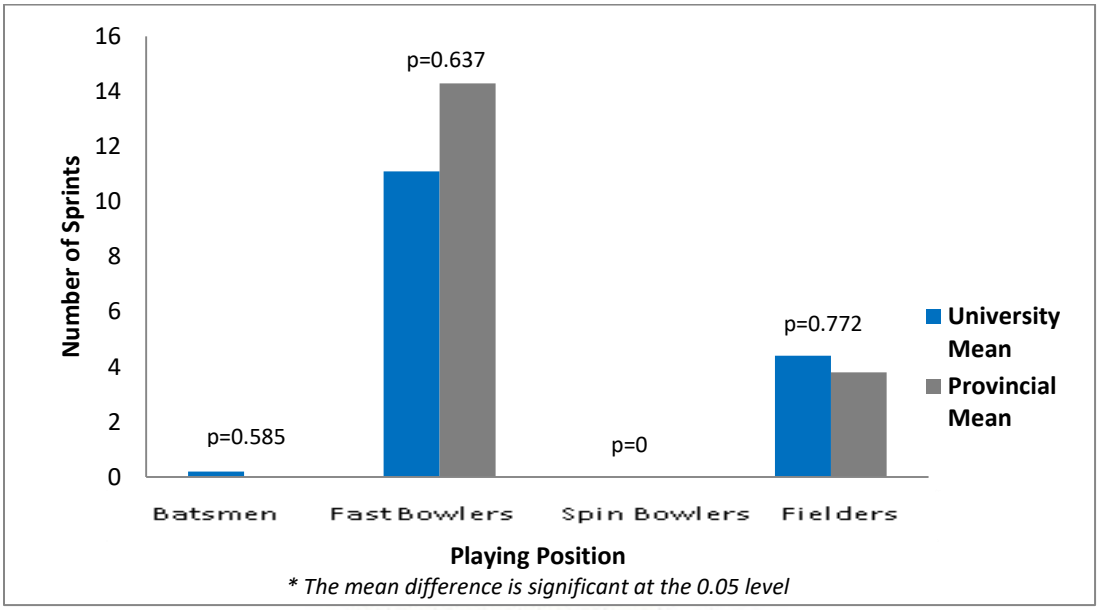

Figure 10: Number of sprints per playing position at training for university and provincial players

University and Provincial fast bowlers were significantly different (p=0.014) from one another for average distance per sprint at training (Figure 11). Provincial fast bowlers (23.4m) and provincial fielders (12.9m) covered a greater average distance per sprint than their opposing university players (fast bowlers 12.1m; fielders 9.4m) at training did. Batsmen and spin bowlers for both university and provincial teams covered a relatively low average distance per sprint at training (0 – 0.5m).

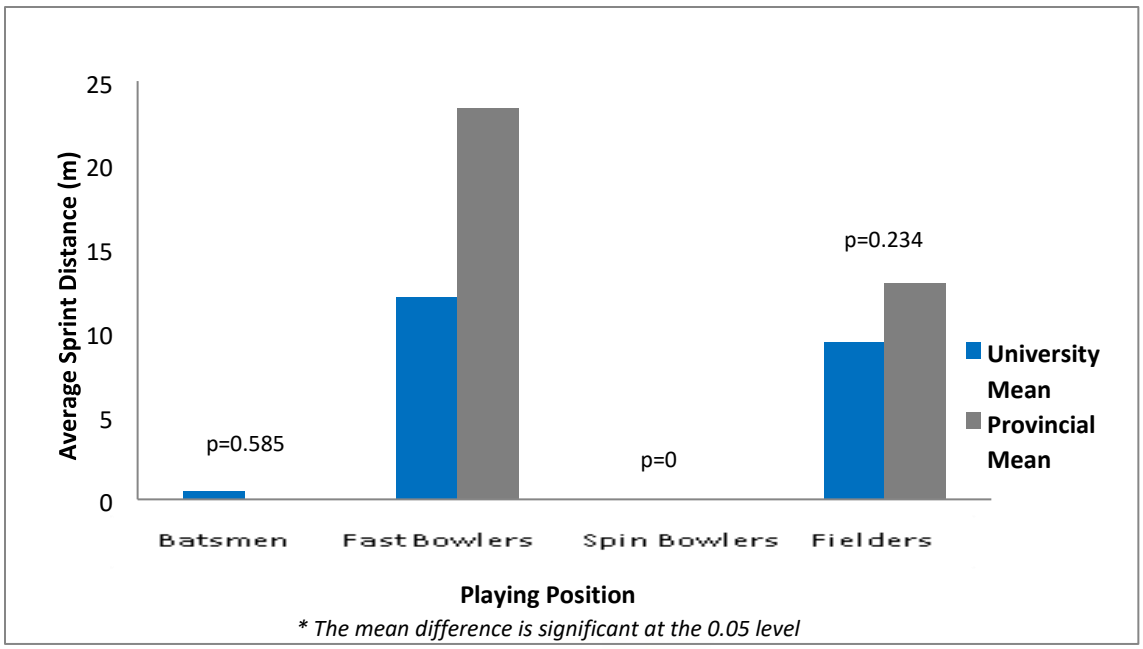

Figure 11: Average sprint distance per playing position at training for university and provincial players

4.11.2 Comparison of Physiological Responses for University and Provincial Players at Training

Figures 12 and 13 are a summary statement of the average heart rates university cricket players and provincial cricket players reached during a training session per playing position as well the maximum heart rate reached per playing position

University and provincial players had no significant differences ($p>0.05$) between them for the average heart rates reached during training (figure 12). University players reached a higher average heart rate for all playing positions at training in comparison to provincial players except for spin bowlers. University fast bowlers had the highest average heart rate (143.5bpm) at training while provincial fielders had the lowest average heart rate (120.5bpm).

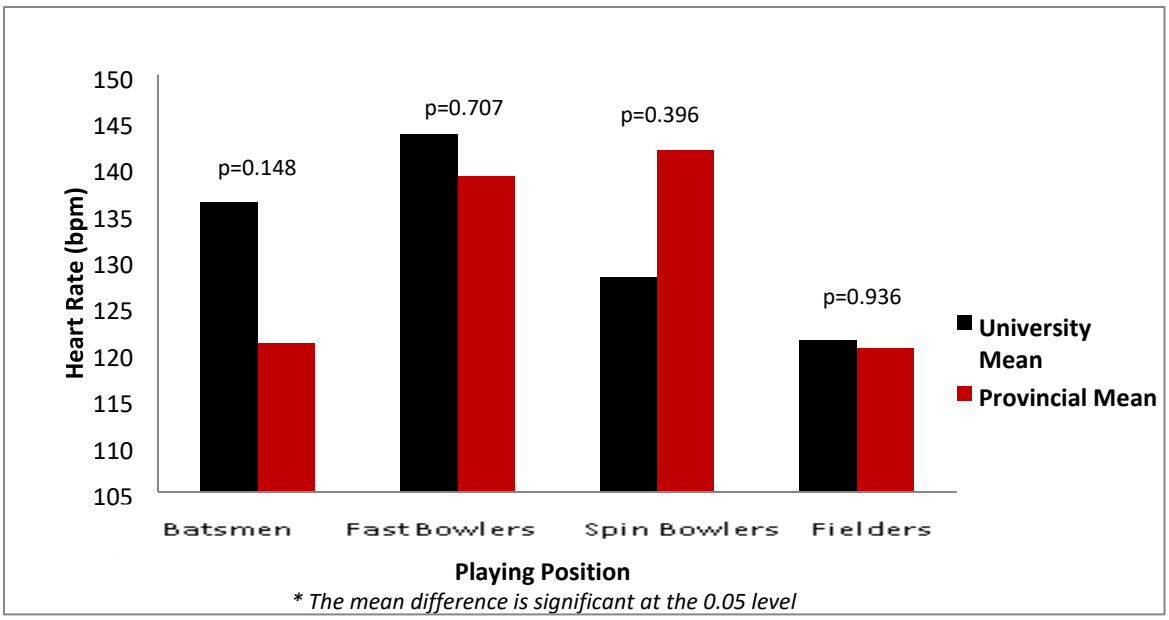

Figure 12: Average heart rate for playing position at training for university and provincial players.

University and provincial players had no significant differences ($p>0.05$) between them for maximum heart rate reached during training (figure 13). University players had higher maximum heart rates for all playing positions at training in comparison to provincial players. Fast bowlers had the highest maximum heart rates at training (university 182.2bpm; provincial 176.8bpm) while provincial batsmen (121bpm) and fielders (120.5bpm) had the lowest maximum heart rates.

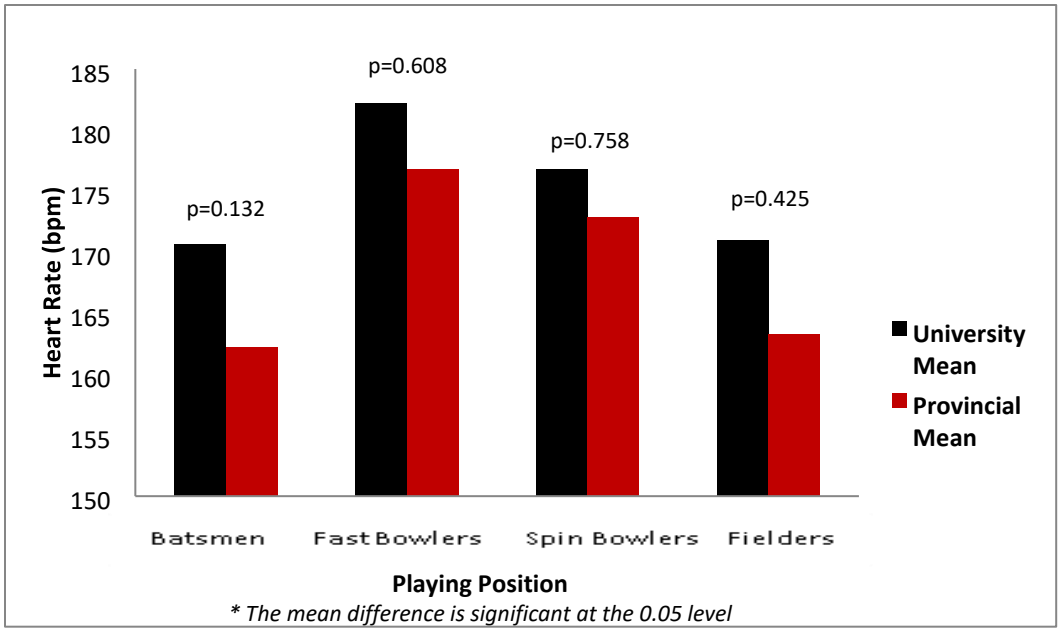

Figure 13: Maximum heart rate per playing position at training for university and provincial players.

4.11.3 Comparison of Movement Variables for University and Provincial Players during a ODG

Figures 14 and 15 are a summary statement of the amount of sprints university cricket players and provincial cricket players do during a ODGs per playing position as well as the average distance per sprint per playing position.

There were no significant differences ($p<0.05$) between university and provincial players during a ODGs for all playing positions (Figure 14). Provincial batsmen (19.4) and fielders (9) did a higher number of sprints than university batsmen (17.9) and fielders (8.1). University Fast bowlers (30.5) and spin bowlers (9) did a higher amount of sprints than provincial fast bowlers (17.2) and spin bowlers (4.5)

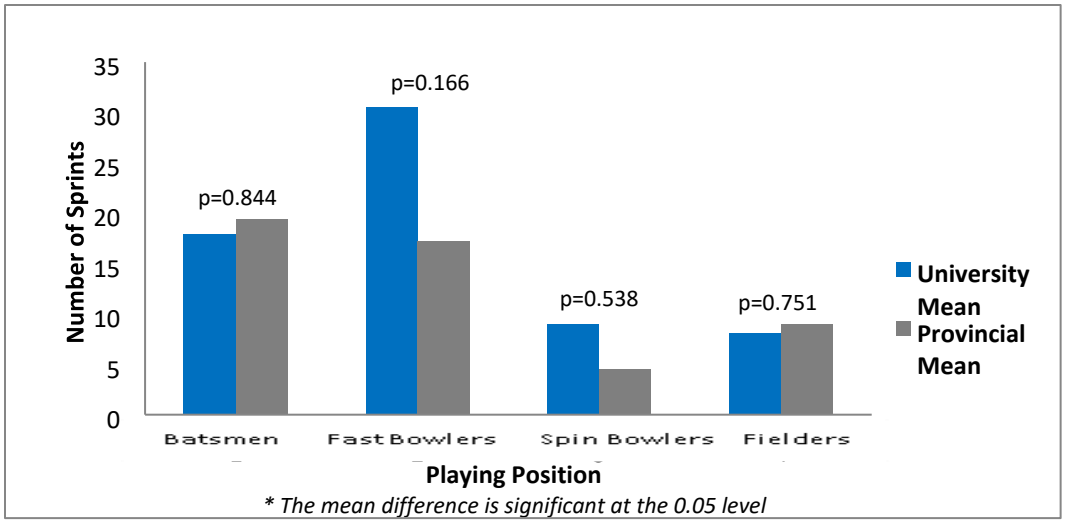

Figure 14: Number of sprints per playing position during a ODGs for university and provincial players

University and provincial spin bowlers differed significantly (p=0.015) for the average distance per sprint during a ODGs (figure 15), all other playing positions had no significant differences (p<0.05) in this regard. University players covered a greater average distance per sprint for all playing positions during a ODGs (batsmen 12.4m; fast bowlers 22.1m; spin bowlers 21.1m) except fielders (16.7m) than provincial players (batsmen 11.4m; fast bowlers 17.1m, spin bowlers 9.2m, fielders 16.8m).

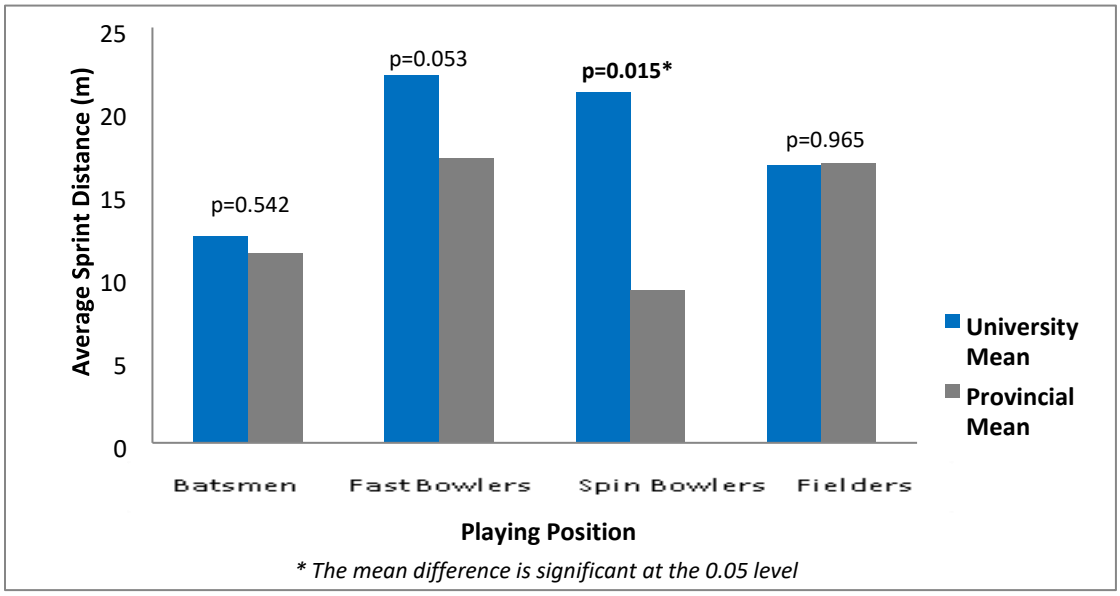

Figure 15: Average sprint distance per playing position during a one-day game for University and Provincial players

4.11.4 Comparison of Physiological responses for University and Provincial Players at during a ODG.

Figures 16 and 17 are a summary statement of the average heart rates university cricket players and provincial cricket players reached during a ODGs per playing position as well the maximum heart rate reached per playing position.

University and provincial players had no significant differences ($p<0.05$) between them for the average heart rates reached during a ODGs (Figure 16). Provincial players had higher average heart rates during a game for all playing positions except fast bowlers. Provincial spin bowlers had the highest average heart rate (199.5bpm) during a game while university fielders had the lowest average heart rate (119.3bpm).

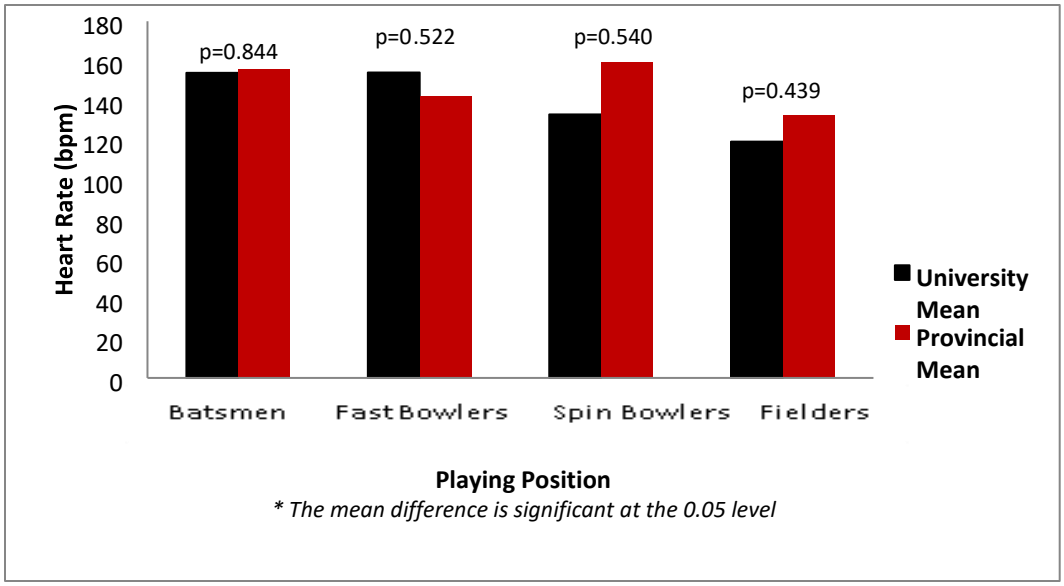

Figure 16: Average heart rate per playing position during a ODGs for university and provincial players.

University and provincial players had no significant differences ($p<0.05$) between them for maximum heart rates reached during a ODGs (Figure 17). University players had higher maximum heart rates for all playing positions except spin bowlers. University fast bowlers reached the highest maximum heart rate (199.8bpm) while university spin bowlers reached the lowest maximum heart rate (176bpm).

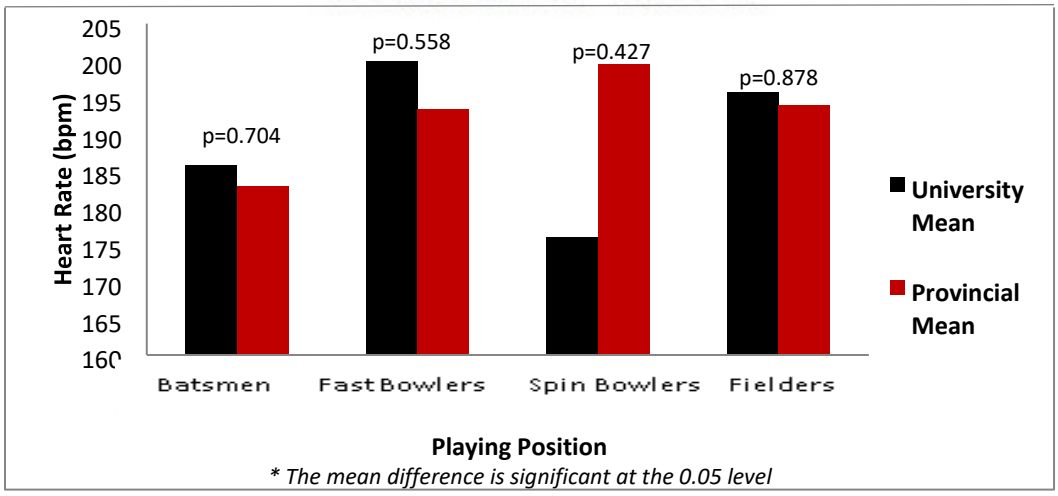

Figure 17: Maximum heart rate per playing position during a ODGs for university and provincial cricket players.

CHAPTER 5

DISCUSSION

The main interest of this study, which focuses on the demands of cricket training and ODGs, is to establish whether the players' training is aligned with the demands of the game. The study employed a quantitative design and numerical data were collected to describe and analyze the physical demands of ODGs and the training sessions preceding these games. Furthermore, it is descriptive and comparative as it also compared the results for different sub-disciplines within the game, as well as players competing at provincial and university levels. The participants consisted of university and provincial, male cricket players.

5.1 Movement Patterns of University Cricket Players

The greater part of the distances covered by university cricket players in the different movement categories consisted of low intensity activity such as walking and jogging. Fast bowlers covered greater distances during training and the ODG compared to all other playing positions and they covered the greatest distances for high intensity activity such as striding and sprinting. These results concur with those reported by Petersen et al, (2010) who found fast bowlers to cover 20–80% greater total distances, greater distances during high-intensity movement patterns (sprinting and striding), sprinted up to 8 times more often, and had at least 35% less recovery time between high-intensity efforts. A comparison of the demands of a single training session to a ODG, revealed that cricketers cover much shorter distances during training, however it needs to be kept in mind that there were two training sessions in the week leading up to the game. Considering this, it can be assumed that those university batsmen cover similar total distances in training and in the game situation (840m X 2=1.67km). This is true for low intensity movement categories (walking,

jogging), however with regards to higher intensity movement categories (running, striding, sprinting) batsmen covered much greater distances during the game in comparison to training where less than 1m of sprinting was done while during a ODG, university batsmen did 135m of sprinting. A study conducted by Stretch et al, (2000) which reviewed batting in men's cricket, found that cricketers rarely sprint more than ±70- 80 m, with a distance of ~ 20 m the most common.

University fast bowlers covered close to twice the distance during the ODG (8.2km) in comparison to training during the week (2.7km x2 sessions). This is also true for the distance covered during high-intensity movements such as sprinting, where fast bowlers cover 1.1km during a game and 312m (156m X 2) at training. This is similar to the results reported by Duffield, Carney and Karppinen (2009), McNamara et al, (2013) and Petersen et al, (2010) who found that fast bowlers sprinted twice as often, covered over three times the distance sprinting, with much smaller work to-recovery ratios than other positions.

Spin bowlers covered long distances during a ODG game (7.1km) which are at least twice the distance they covered during training (2.2kmx2). However, this includes fielding which they did in between bowling overs. Similar to batsmen and fast bowlers, the sprinting of spin bowlers during training compared to the ODG is low.

The greatest discrepancy between training and the ODG 'total distances' covered, was found for fielders (2km vs 5.8km). This difference can be ascribed to the fact that the duration of training sessions is much shorter than the duration of a fielding innings during a ODG.

Aughey (2011) indicates that it is not necessarily useful to report the total distance that athletes cover in field sports without reference to the time spent engaged in actual match play. A more

accurate indication of the difference for fielders is the percentages of each movement category that make up the total distance covered. University fielders spent 67% of the time walking at training compared to the 76% during the ODG. In terms of sprinting, fielders spent 2% of the time sprinting in comparison to 1.7% during the game. The main reason for this discrepancy is that training does not emulate the game situation. Players do different skills and activities during training. During a game, fielders are compelled to occupy their fielding positions and only get "involved" when the ball comes to their direction.

Wicketkeepers did not engage in any high-intensity movement during training covering zero meters. This is similar to the ODG situation where the high-intensity movement was also low with 80m, 49m and 17m covered for running, striding and sprinting respectively. Petersen et al, (2010) who found that wicketkeepers rarely sprinted support this finding, despite still covering a daily total distance of 16.6+2.1 km. Lemmer (2011), highlighted the fact that wicketkeepers also play as batsmen, which is an important fact to consider when addressing the demands of the position.

5.2 Comparison of Movement Patterns of University Cricketers across Playing Positions during a Training Session and a ODG.

Significant differences were found across all playing positions and movement categories during the training sessions and the ODGs for university, male cricket players. Batsmen covered the shortest distances during training for all movement categories compared to other playing positions. This is indicative of the fact that there are differences in the physical demands of batsmen compared to other playing positions at training. It is important to keep in mind that the physical demands placed on batsmen during a game are directly related to the time he spends at the crease. This can differ from game to game for the same batsmen.

Fast bowlers covered the greatest distances for all movement categories when compared to other playing positions, and were significantly different to batsmen and fielders only for lower intensity movements while differing significantly from all other playing positions during high-intensity movement. This indicates that fast bowlers operate at a greater capacity during training in comparison to other playing positions, this corresponds with research by Vickery et al, (2018); Peterson et al, (2010), McDonald et al, (2013). University spin bowlers differed significantly to batsmen and fielders during low-intensity movement while differing significantly to fast bowlers only in high-intensity movement. University fielders differed significantly from all types of bowlers during low-intensity movement while differing significantly from fast bowlers only during high intensity activity. No previous evidence was found relating to differences between sub-disciplines in this regard which highlights the importance of these findings.

During a ODG batsmen covered the shortest total, walking and jogging distances when compared to all other playing positions. The running, striding and sprinting distances covered by batsmen were significantly different to fast bowlers only. For high-intensity movement, fast bowlers differed significantly from all other playing positions with the exception of 'striding' for spin bowlers. Spin bowlers differed significantly from batsmen for all low-intensity movements.

5.3 Movement Patterns of University Players during a Training Session Compared to ODGs.

The results of the current study showed that the demands of the ODG exceed the demands of training sessions across all playing positions for university cricketers. University batsmen covered significantly greater distances for all high-intensity movement categories during the ODG in comparison to training. Fast bowlers also covered significantly greater distances during the ODG in comparison to training for all movement categories except for striding. McNamara et al, (2013)

also found that fast bowlers performed greater competition total distances, including greater distances at low and high speeds compared to other playing positions. Spin bowlers covered longer low-intensity distances and sprinting during the ODG compared to training. Fielders showed significant differences for all movement categories between training and the ODG.

5.4 Movement Variables and Physiological Responses of University Players during a Training Session Compared to a ODG.

Low et al, (2013) reported that conditioning drills were twice as long in duration as skill drills and twice as intense as both the skill and game simulation drills. This suggests that different types of training scenarios can influence the demands of the particular training session. When investigating the number of sprints per playing position for university cricketers between training and games, it was observed that all playing positions did a greater number of sprints during a game in comparison to training. Sprints during cricket are often centered about crucial match situations such as running between the wickets, the run-up, and delivery during fast bowling or sprinting to field a ball (Lockie et al., 2014). This could be the reason for the relatively low distance sprinted during cricket games and training across playing positions. Fast bowlers did the highest number of sprints during both training and the ODG, which indicates that the demands are greater for fast bowlers in comparison to other playing positions. The number of sprints done during training in comparison to a game differed significantly for all playing positions except fielders. This suggests that cricket players do not simulate match demands closely enough during training.

The average distance per sprint showed similar patterns to the number of sprints with fast bowlers covering the greatest distance per sprint. Vickery et al, (2017) and Petersen et al, (2010) found that fast bowlers performed the greatest workload of any position in cricket. The average distance per

sprint also differed significantly for all playing positions between trainings and games which further suggests that cricketers under prepare for the demands that need to be met during a match.

When exploring the average heart rates per playing positions for university cricket players between training and the ODG it was observed that university cricketers have higher average heart rates during games across all playing positions in comparison to training, except for fielders. This suggests that internal physiological demands are greater during a game in comparison to training. Low et al, (2013) suggested that training imitates or surpasses cricket match demands in conditioning-type drills but not in simulation or skill-based drills. This suggests that match demands for batsmen are not adequately met during training when skill based sessions only are focused on. Petersen et al, (2010) found that the capacity of work undertaken while batting is directly related to the time a batsman remains at the crease during a game. Maximum heart rates reached by players during competition were higher in comparison to training for all playing positions except spin bowlers. This shows that spin bowlers are internally exerted more than during their training.

5.5 Movement Patterns of Provincial Cricket Players

Cricket players at provincial level showed similar movement patterns per movement category as university level players during training and ODGs. Provincial batsmen covered the lowest absolute total distance during both training sessions (751m x2 training sessions) and in the ODG (1.68km). A batsman that can successfully bat throughout an entire innings will cover 8.7 km during One-Day cricket (Petersen et al., 2010). Pote and Christie (2014) suggested that internal responses plateau further into batting innings, however, perceived workload increased.

Most of the total distance covered by provincial batsmen during training and the ODG consisted of low-intensity movement (83%). While their high-intensity movement consisted of 137m and 135m striding and sprinting respectively. This indicates the physical exertion in terms of movement patterns for provincial batsmen at training was less than during the ODG. According to Duffield and Drinkwater (2008), the time spent on the pitch while scoring a one-day century consists predominantly of low-intensity activity modes such as standing, walking and to a lesser extent jogging.

Provincial fast bowlers covered the greatest absolute total distance during training (2.4km x2) and during the ODG (8.2km) in comparison to all other playing positions. This is also true for all movement categories. These findings are in line with those reported by McNamara et al, (2013) who found that fast bowlers consistently performed at greater intensities and performed more high speed running than non-fast bowlers

The differences between the distances covered during training and the ODG could be ascribed to the differences in the duration of training sessions compared to a match. Petersen et al, (2010) and Vickery et al, (2017), agreed that the volume and duration of movement that a player in a particular position undertook depends largely on the game circumstances. Provincial fast bowlers cover similar percentage of distances in lower intensity movements, 56%, 9% and 3% walking, jogging and running respectively at training and 68%, 11% and 3% during a ODG. For higher intensity movements, striding is closely matched between training (6%) and a game (4%), while sprinting at training is 23% of the distance covered and 13% for a game. This indicates that the physical exertion in terms of movement patterns for provincial fast bowlers at training is closely matched for all movement categories during a ODG except for sprinting which is higher during training in comparison to a game. This could be due the match situation of the ODG used for data collection

Provincial spin bowlers covered more than twice the absolute total distance during the ODG (7.1km) in comparison to training (2.4km x2 training sessions). They cover similar percentages of distance in all movement categories between training and the ODG. The majority of the movement for spin bowlers was spent on low-intensity activities during training with 76%, 22% and 1% for walking, jogging and running respectively while 72%, 20%, and 3% were covered in the same categories during a ODG. For high-intensity movement, provincial spin bowlers covered 0.5% and 2% of the distance by striding and sprinting respectively while covering 0.3% and 2% for the same movements during a ODG. It can be deduced that the physical exertion in terms of movement categories for provincial spin bowlers at training, is closely matched for all movement categories of a ODG.

Provincial fielders, similar to spin bowlers and fast bowlers, covered more than twice the distance during a game (5.7km) in comparison to training in the week (1.3km x2 training sessions). Fielders covered slightly higher percentages in most movement categories at training in comparison to a ODG. During lower intensity movement at training, fielders covered 53%, 30%, and 5% walking, jogging and running respectively while covering 77%, 16% and 3% during a ODG. High-intensity movement for fielders made up 9% and 2% for striding and sprinting respectively at training, while it was 2% and 2% during a ODG for the same movements. It is evident that provincial fielders do slightly more high-intensity activity during training in comparison to a ODG, a finding which is supported by Rampinini et al, (2014).

5.6 Comparison of Movement Patterns of Provincial Cricketers across Playing Position during a Training Session and a ODG

There were significant differences across all playing positions and movement categories during training and ODGs for provincial cricket players. As was the case with university players, provincial batsmen covered the shortest distances for all movement categories during training compared to other playing positions.

Batsmen covered the shortest distances for low-intensity activity in comparison to all other playing positions. Batsmen differed significantly from fast bowlers (for walking, jogging and sprinting) and fielders (walking). Fast bowlers covered the greatest distance for all movement categories in comparison to all other playing positions and differed significantly from batsmen for all movement categories except running and striding. Fast bowlers also differed to spin bowlers for sprinting distance covered. Spin bowlers covered the lowest distance for high-intensity movement during the ODG in comparison to all other playing positions. Spinners differed significantly to fast bowlers only for sprinting distances covered. Fielders differed significantly to batsmen for walking distance covered as well as sprinting distance covered by fast bowlers. Vickery et al, (2018) found similar results with regards to spin bowling and fast bowling.

Spin bowlers performed at a much lower intensity compared to fast bowlers during both training and the ODG. The differences can be ascribed to movements associated with the different bowling types especially their run-ups.

5.7 Movement Patterns of Provincial Players during a Training Session Compared to the ODG.

Similar to university players, provincial cricketers covered higher mean distances for all high intensity movement categories during an ODG in comparison to training. Higher intensity movement for batsmen during the ODG was significantly higher during the game compared to training. Fast bowlers differed significantly for all movement categories between training and the ODG except for sprinting. Higher mean distances were observed for all movement patterns during a game in comparison to training which reveals the possibility that demands of a game are more than that of training. Vickery et al, (2016) suggested however that the technical demands of traditional net cricket training exceeded that of a typical match for each playing position. Although spin bowlers covered greater distances during a match in comparison to training for all movement patterns, significant differences were only observed for running and sprinting. Fielders covered greater distances in all movement categories during a game in comparison to training except for striding. Significant differences were observed for walking and sprinting between training and a game. This shows that very low intensity and high-intensity movement is substantially different between training and games for fielders.

5.8 Movement Variables and Physiological Responses of Provincial Players during a Training Session Compared to a ODG.

Stretch et al, (2000) proposed that cricketers need to be able to repeat many intensive efforts lasting between 10 and 20 seconds on average. When examining the number of sprints provincial cricket players execute during training in comparison to a game per playing position, similar patterns to university players emerged. Differences between training and the ODG for batsmen and fast bowlers were significant. This suggests that at provincial level, batsmen and fast bowlers do not

exert themselves enough during training compared to the demands of the game. This is in agreement with Vickery et al, (2017) and Duffield and Drinkwater (2008) who found that the present training methods used in cricket may not best imitate the demands of match-play.

An analysis of the mean heart rates of provincial players revealed that similar to university players all provincial players across all playing positions had higher average heart rates during a ODG in comparison to training. This once again shows that internal demands are greater during a game compared to training. Scanlan et al, (2016) found that higher level players had lower heart rates than club players during ODGs. Maximum heart rates reached by all provincial cricketers were found to be higher during ODGs compared to training sessions.

5.9 Comparison of the Movement Patterns between University and Provincial Cricketers

The only difference found between university and provincial players about training was that provincial fast bowlers covered longer sprint distances. As Low et al, (2013) pointed out, it is important to keep in mind that not all practices are of equal quality and duration. No differences were found between the movement patterns of university and provincial cricket players during a ODG.

Fast bowlers at both provincial and university levels performed at the highest intensity compared to the other positions. Petersen et al, (2010) reported that this is true for all formats of the game. Vickery et al, (2017) found that the physical and physiological demands of bowlers differ significantly over the different game and training formats. They found that shorter match formats lead to a greater physical and physiological response especially amongst fast bowlers (Vickery et al., 2017).

5.10 Comparison of the Movement Variables and Physiological Responses between University and Provincial Cricketers

Provincial and university players further completed the same number of sprints during training and the ODG. However, provincial players covered greater average sprint distances during training while university spin bowlers covered greater distances during the ODG.

Their average and maximum heart rates were found to be similar during training and during the ODG. Although Scanlan et al, (2016) suggested that higher-level players are likely to possess greater levels of training experience and fitness, the similarities between players performing at different levels found in the present study are in line with the findings reported by Petersen et al, (2010).

5.11 Conclusion

The main aim of this study was to provide a quantitative description and comparative analyses of the movement patterns and demands of pre-game training and ODGs of university and amateur provincial male cricket players.

The findings of this study unequivocally highlight the differing internal and external demands placed on players in the different playing positions during training and ODGs for both university and provincial levels. This information is a valuable source in the design of training programmes, which are aligned with the physical demands, and movement patterns of ODGs. Cricket training is generally skills and activity based (batting, bowling, wicket keeping and fielding) and seldom replicates the game situation. Coaches and trainers should develop training programmes, which are aligned with the demands of the games and of the different playing positions identified in this study. Game-based training should therefore also form part of the training regimes of teams.

LIMITATIONS

Because the equipment is quite expensive not many units were used, limiting the sample size in the study. Units are also operated manually which poses a problem for measurement accuracy while players are on the field of play and one cannot get onto the field to switch the device on and off during activity.

RECOMMENDATIONS

Further research on this topic can possibly look at a combination of time-motion analysis as well as GPS units to gather data and refine the accuracy of information observed. If the current study could be duplicated and conducted over a longer period including more players, training and ODGs it could further assist coaches and trainers to inform match preparations in order to ensure optimal physical readiness. Software developers could also possibly look at creating units, which can be remotely operated to assist in breaking down the different phases of play even more.

REFERENCES

Anand, D. (2016). From the field: Medicine ball training for Cricket. Journal of Australian Strength and Conditioning, 24(4), 29-41.

Aughey, R. (2011). Applications of GPS Technologies to Field Sports. International Journal of Sports Physiology and Performance, 6, 295-310.

Bartlett, R.M. (2003). The science and medicine of cricket: an overview and update. Journal of Sports Sciences, 21, 733-752.

Christie, C. (2008). The Physical Demands of Batting and Fast Bowling in Cricket. An International Perspective on Topics in Sports Medicine and Sports Injury, 17, 321-332.

Cotterill, T. (2011). Experiences of Developing Pre-performance Routines with Elite Cricket Players. Journal of Sports Psychology in Action, 2, 81–91.

Cummins, C., Orr, R., O'Connor, H. & West, C. (2013). Global Positioning Systems (GPS) and Microtechnology Sensors in Team Sports: A Systematic Review. Journal of Sports Medicine, 43, 1025.

Cunniffe, B., Proctor, W., Baker, J.S. & Davies, B. (2009). An evaluation of the physiological demands of elite rugby union using Global Positioning System tracking software. Journal of Strength and Conditioning Research, 23, 1195-203

Duffield, R. & Drinkwater, E.J. (2008). Time-motion analysis of Test and One-Day international cricket centuries. Journal of Sports Sciences, 26, 457 – 464.

Duffield, R., Carney, M., & Karppinen, S. (2009). Physiological responses and bowling performance during repeated spells of medium-fast bowling. Journal of Sports Sciences, 27(1), 27–35.

Edgecomb, S.J. & Norton, H.I. (2006). Comparison of global positioning and computer-based tracking systems for measuring player movement distance during Australian football. Journal of Sciences and Medicine in Sport, 9(1-2), 25-32.

Feros, S.A., Young, W.B. & O'Brien, B.J. (2014). The relationship between selected physical qualities and bowling performance with "match-intensity" and maximal-effort" deliveries in cricket pace-bowlers. Journal of Australian Strength and Conditioning, 22(5), 120-123.

Lemmer, H.H. (2011). Performance measures for Wicket Keepers in cricket. South African Journal for Research in Sport, Physical Education, and Recreation, 2011, 33(3), 89-102.

Houghton, L., Dawson, B., Rubenson, J. & Tobin, M. (2011). Movement patterns and physical strain during a novel, simulated cricket batting innings (BATEX). Journal of Sports Sciences, 29, 801-809.

Johnston, R.J., Watsford, M.L., Kelly, S.J., Pine, M.J. & Spurrs, R.W. (2014). Validity and interunit reliability of 10Hz and 15Hz GPS units for assessing athlete movement demands. Journal of Strength and Conditioning Research, 28(6), 1649 -1655.

Lockie, R.G., Callaghan, S.J. & Jeffriess, M.D. (2014). Acceleration Kinematics in Cricketers: Implications for Performance in the Field. Journal of Sports Science and Medicine, 13, 128-136.

Low, J., Williams, M.A., McRobert, A.P. & Ford, P.R. (2013). The microstructure of practice activities engaged in by elite and recreational youth cricket players, Journal of Sports Sciences, 31, 1242–1250.

MacDonald, D., Cronin, J., Mills, J. &Stretch, R. (2013). Wicket keeping in Cricket: A Literature Review. International Journal of Sports Science & Coaching, 8, 531.

McNamara, J., Gabbett, T, J., Naughton, G., Farhart, P. & Chapman, P. (2013). Training and Competition Workloads and Fatigue Responses of Elite Junior Cricket Players. International Journal of Sports Physiology and Performance, 8, 517-526

McNamara, D.J., Gabbett, T.J., Chapman, P., Naughton, D. & Farhart, P. (2015). The Validity of Microsensors to Automatically Detect Bowling Events and Counts in Cricket Fast Bowlers. International Journal of Sports Physiology and Performance, 10, 71-75.

Noakes, T. & Durandt, J. (2000). Physiological requirements of cricket. Journal of Sports Sciences, 18, 919-929.

Noorbhai, M.H. & Noakes, T.D. (2015). Advances in cricket in the 21st century: Science, performance, and technology. African Journal for Physical, Health Education, Recreation and Dance, 21(4:2), 1310-1320.

Petersen, C, J., Pyne, D., Dawson, B., Portus, M. & Kellett, A. (2010). Movement patterns in cricket vary by both position and game format. Journal of Sports Sciences, 28, 45–52.

Petersen, C, J., Pyne, D., Dawson, B. & Portus, M. (2009). Validity and Reliability of GPS Units to Monitor Cricket-Specific Movement Patterns, 4, 381-393.

Petersen, C., Pyne, D. B., Portus, M. R., Karppinen, S. & Dawson, B. (2009). Variability in movement patterns during one-day internationals by a cricket fast bowler. International Journal of Sports Physiology and Performance, 4, 278-281.

Pote, L. & Christie, C. (2013). Impact of a simulated one-day international century on batting performance in cricket. Journal of Science and Medicine in Sport, 16, 93-94.

Pote, L. & Christie, J. (2014). Physiological and Perceptual Demands of High-Intensity Sprinting Between the Wickets in Cricket. International Journal of Sports Science & Coaching, 9, 13751382.

Pote, L. & Christie, C.J. (2016). Strength and Conditioning Practices of University and High School level cricket coaches: A South African Context. Journal of Strength and Conditioning Research. 30(12), 3464-3470.

Rampinini, E., Alberti, G., Fiorenza, M., Riggio, M., Sassi, R., Borges, T.O. & Coutts, A.J. (2014). Accuracy of GPS Devices for Measuring High-intensity running in Field-based Team Sports. International Journal of Sports Medicine, 36(11), 49-53.

Reardon, C., Tobin, D.P. & Delahunt, E. (2015). Application of Individualized Speed Thresholds to Interpret Position Specific Running Demands in Elite Professional Rugby Union: A GPS Study, PLoS ONE, 10(7): e0133410. https://doi.org/10.1371/journal.pone.0133410.

Scanlan, A.T., Berkelmans, D.M., Vickery, W.M. & Kean, O.C. (2016). A Review of the Internal and External Physiological Demands Associated With Batting in Cricket. International Journal of Sports Physiology and Performance, 11, 987 -997.

Stretch, R, A., Bartlett, R. & Davids, K. (2000). A review of batting in men's cricket. Journal of Sports Sciences, 18, 931 - 949.

Vickery, W.M., Dascombe, B.J., Baker, J.D., Higham, D.G., Spratford, W.A. & Duffield, R. (2014). Accuracy and reliability of GPS devices for measurement of sports-1 specific movement patterns related to cricket, tennis, and field-based 2 team sports. Journal of Strength and Conditioning Research, 28(6), 1697-1705.

Vickery, W., Dascombe, B., Duffield, R., Kellett, A. & Portus, M. (2013). The influence of field size, player number and rule changes on the physiological responses and movement demands of small-sided games for cricket training. Journal of Sports Sciences, 31, 629 - 638.

Vickery, W., Dascombe, B. & Duffield, R. (2016). The Association between Internal and External Measures of Training Load in Batsmen and Medium-Fast Bowlers during Net-Based Cricket Training. International Journal of Sports Physiology and Performance, 12(2), 247-253.

Vickery, W., Dascombe, B.J. & Scanlan, A.T. (2018). A review of the physical and physiological demands associated with cricket fast and spin bowlers. International Journal of Sports Science & Coaching, 13(2), 290–301.

Vickery, W., Duffield, R., Crowther, R., Beakley, D., Blanch, P. & Dascombe, B. J. (2018). Comparison of the physical and technical demands of cricket players during training and matchplay. Journal of Strength and Conditioning Research, 32(3), 821 - 829.

Webster, J. & Roberts, J. (2011). Determining the effect of cricket leg guards on running performance. Journal of Sports Sciences, 29(7), 749–760.

Appendix A: Information Sheet

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2350 Fax: 27 21-959 3688
E-mail: atravill@uwc.ac.za

Project title: An assessment of the physical fitness demands of One-Day cricket using Global Positioning System tracking software

What is this study about?

This is a research project being conducted by Zane Webster at the University of the Western Cape. We are inviting you to participate in this research project because you could provide us with meaningful information regarding the status of the Physical Demands required in cricket. The purpose of this research is to investigate the physical demands of cricket, by using GPS units, during a competitive one day match and to compare this to physical demands of cricket training. Furthermore, it aims to investigate possible differences, if any, between the physical demands of various disciplines within the game in competition and during training.

What will I be asked to do if I agree to participate?

You will be asked to:

- Be fit with a GPS unit for the duration of the training sessions and matches. The GPS unit will be strapped to a vest that one can wear over or under gear.
- The unit sits inside a pouch on the back of the vest, located between the shoulder blades.

Would my participation in this study be kept confidential?

The researchers undertake to protect your confidentiality. To ensure your anonymity the following steps will be taken:

- **Data Collection:** A code will be given for each player on. Through the use of an identification key, the researcher will be able to link your information to your identity. Only the researcher will have access to the identification key. To help protect your confidentiality all information gathered will be stored in a locked filing cabinet. No unauthorized party will be able to access the information.
- If we write a report or article about this research project, your identity will be protected.

What are the risks of this research?

There may be some risks from participating in this research study. All human interactions carry some amount of risk. Some of the known risks that may result from participating in the research are psychological and physical. If participants are fatigued or uncomfortable with wearing the GPS unit during training or a match they could withdraw from the study. We will nevertheless minimize such risks and act promptly to assist you if you experience any discomfort, psychological or otherwise during the process of your participation in this study. Where necessary, an appropriate referral will be made to a suitable professional for further assistance or intervention. **What are the benefits of this research?**

This research could be beneficial to coaches, teams and individual players within those teams involved in the study in that it will reveal a set of reference values which will be useful in investigations on player selection, training programme development for teams as well as individual athletes within those teams.

Do I have to be in this research and may I stop participating at any time?

Partaking in this study is entirely voluntary. You may elect not to take part at all. If you agree to participate in this research, you may stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.

Is any assistance available if I am negatively affected by participating in this study?

The researcher will be available for you to contact should you be negatively affected by any aspect of the research at any time and an appropriate course of action will be followed with the support of the researcher.

What if I have questions?

This research is being conducted by Zane Webster and the Department of Sport, Recreation and Exercise Science (SRES) at the University of the Western Cape. If you have any questions about the research study itself, please contact Zane Webster at 0846958853 or e-mail zane.webbo@gmail.com or 3001759@myuwc.ac.za

Should you have any questions concerning this study and your rights as a research participant or if you wish to report any problems you have experienced related to the study, please contact:

Head of Department and Supervisor: Prof Andre Travill

University of the Western Cape

Private Bag X17

Bellville 7535

Email: atravill@uwc.ac.za

Dean of the Faculty of Community and Health Sciences:

Prof José Frantz

University of the Western Cape

Private Bag X17 Bellville

7535

chsdeansoffice@uwc.ac.za

Appendix B: Consent Form

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2350 Fax: 27 21-959 3688
E-mail: atravill@uwc.ac.za

Title of Research Project: ***An assessment of the physical fitness demands of One-Day cricket using Global Positioning System tracking software***

The study has been described to me in language that I understand. My questions about the study have been answered. I understand what my participation will involve and I agree to participate in my own choice and free will. I understand that my identity will not be disclosed to anyone. I understand that I may withdraw from the study at any time without giving a reason and without fear of negative consequences or loss of benefits.

Participant's name……..

Participant's signature…….

Date……

Appendix C: University Cricket Club Permission Letter

ACCESS LETTER REQUESTING PERMISSION TO CONDUCT RESEARCH

University of the

Western Cape

Private Bag X 17,

Bellville 7535,

South Africa

Date

Dear …

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

I am a registered Master's student in the Department of Sports, Recreation and Exercise Science at the University of the Western Cape. My supervisor is Prof Andre Travill.

The proposed topic of my research is an assessment of the physical fitness demands of One-Day cricket using Global Positioning System tracking software. It is my intention to use players which play at a high level of cricket in the province but not professionally, to gather information regarding the physical demands of cricket for the purposes of the research. The purpose of this study is to:

(a) gather data on the physical demands of One-Day cricket training sessions and games, using GPS units, in order to identify whether or not they match

(b) use this data to investigate possible differences, if any, between the physical demands of the various disciplines

(c) compare this information between professional and amateur players.

I am hereby seeking your consent to use the members of your cricket squad as part of the research study. To assist you in reaching a decision, I have attached to this letter:

(a) A copy of the ethical considerations handed to the University for approval.

(b) A copy the research proposal handed to the University for approval.

Should you require any further information, please do not hesitate to contact me or my supervisor. Our contact details are as follows:

Researcher – Zane Webster (0846958853 or zane.webbo@gmail.com)

Research Supervisor – Prof Andre Travill ((021) 959 2350 or atravill@uwc.ac.za)

Appendix D: Provincial Cricket Association Permission letter

ACCESS LETTER REQUESTING PERMISSION TO CONDUCT RESEARCH

University of the

Western Cape

Private Bag X 17,

Bellville 7535,

South Africa

Date

To whom it may Concern

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

I am a registered Master's student in the Department of Sports, Recreation and Exercise Science at the University of the Western Cape. My supervisor is Prof Andre Travill.

The proposed topic of my research is an assessment of the physical fitness demands of One-Day cricket using Global Positioning System tracking software. It is my intention to use players which play at the highest level of cricket in the province, to gather information regarding the physical demands of cricket for the purposes of the research. The purpose of this study is to:

(d) gather data on the physical demands of One-Day cricket training sessions and games, using GPS units, in order to identify whether or not they match

(e) use this data to investigate possible differences, if any, between the physical demands of the various disciplines

(f) compare this information between professional and amateur players.

I am hereby seeking your consent to use your team/s as part of the research study. To assist you in reaching a decision, I have attached to this letter:

(c) A copy of the ethical considerations handed to the University for approval.

(d) A copy the research proposal handed to the University for approval.

Should you require any further information, please do not hesitate to contact me or my supervisor. Our contact details are as follows:

Researcher – Zane Webster (0846958853 or zane.webbo@gmail.com)

Research Supervisor – Prof. Andre Travill ((021) 959 2350 or atravill@uwc.ac.za)

Upon completion of the study, I undertake to provide you with a bound copy of the dissertation.

Your permission to conduct this study will be greatly appreciated.

Yours sincerely,

Zane Webster