EFFECTS OF MINDFULNESS TRAINING ON UNIVERSITY BASKETBALL PLAYERS' TECHNICAL, TACTICAL PERFORMANCE AND MENTAL FATIGUE

By

CAO SHUDIAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

March 2023

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DEDICATION

This thesis is dedicated to

My parents
My sister

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman : Professor Soh Kim Geok, PhD
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Mental fatigue (MF) is a psycho-biological state caused by a prolonged period of demanding cognitive activity. The effects of MF on basketball performance were comprehensively investigated in the literature. However, the effects of MF on basketball technical and tactical performance and the recovery strategy to counteract MF and basketball performance remain unclear. The objective of this study is to investigate the effects of MF on basketball technical and tactical performance and mindfulness training on the recovery of MF, technical and tactical performance among university students. A pre- and post-test approach with cluster Randomized Controlled Trial (cRCT) was applied in this study. The sample size was calculated by the Software package G*Power3.1. Considering the design effect, 54 male basketball players (n=18 each group) were finally recruited from three universities and aged at 18-24 years were randomly assigned into control group (CG), mental fatigue group (MFG) and mental fatigue-mindfulness group (MF-MG). A 30-min Stroop task was first used to induce MF in MFG and MF-MG. Then, the 30-min brief audio mindfulness training was applied in MF-MG. MF and mindfulness state were measured by visual analog scale (VAS) and five facet mindfulness questionnaire (FFMQ) respectively. The basketball performance was recorded in the small side game (SSG). The results from Generalized Estimating Equations (GEE) indicated that MF significantly influenced the attention level with the significant decrease in the score of attention focus (MD=3.61, $p<0.001$) and attention shift (MD=3.11, $p<0.001$) of basketball players; the efficiency score (MD=2.22, $p=0.006$), with significant decreases in the number of points (MD=2.28, $p<0.001$), field goals made (MD=0.94, $p<0.001$) and increase in the number of rebounds (MD=-1.06, $p<0.001$); the tactical performance with significant decreases in the number of ball reversal (BR)(MD=0.56, $p=0.030$), on-ball screen (ONBS)(MD=1.50, $p<0.001$) and increase in dribble penetration into the key area (DPKA)(MD=-1.56, $p<0.001$); the mindfulness state with the significant decrease in the score of mindfulness state (MD=8.39, $p<0.001$) form pre-test to post-test in MFG. On the other hand, the mindfulness training counteracted the effects of MF on the score of attention focus

(MD=0.39, p=1.000) and attention shift (MD=0.28, p=1.000); the efficiency score (MD=-1.78, p p=0.083) including the number of points (MD=-1.44, p=0.056), rebounds (MD=0.17, p=0.058) and field goals made (MD=-0.56, p=0.001); the tactical performance including BR (MD=0.33, p=1.000), ONBS (MD=-0.78, p=0.378) and DPKA (MD=0.22, p=1.000); the score of mindfulness state (MD=-7.33, p<0.001) from pre-test to post-test in MF-MG. Except from pre-test to post-test, just in post-test, results also showed that there was a significant impairment of MF on the score of attention focus (MD=3.78, p<0.001) and attention shift (MD=3.33, p=0.005); efficiency score (MD=2.94, p=0.017) including points (MD=2.50, p<0.001), the number of rebounds (MD=-1.33, p<0.001) and field goals made (MD=1.39, p<0.001); the tactical performance including BR (MD=0.72, p=0.018), DPKA (MD=-1.94, p=0.022) and off-ball screen (OFFBS) (MD=1.00, p=0.025); the score of mindfulness state (MD=7.67, p=0.032) in MFG compared with CG. On the other hand, results showed the recovery of mindfulness training on the score of attention focus (MD=-3.61, p<0.001) and attention shift (MD=-3.00, p=0.008); efficiency score (MD=-2.67, p=0.092) including points (MD=-3.06, p<0.001) and the number of field goals made (MD=-1.22, p<0.001); the tactical performance including BR (MD=-0.78, p=0.013), DPKA (MD=2.39, p=0.004) ONBS (MD=-1.61, p=0.011) and OFFBS (MD=-1.33, p<0.001); the score of mindfulness state (MD=-16.39, p<0.001) in MF-MG compared with MFG at post-test. In conclusion, MF significant impaired the basketball technical and tactical performance, and mindfulness training was an effective method to counteract the negative effects of MF on basketball technical and tactical performance.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN KELETIHAN MENTAL TERHADAP PRESTASI TEKNIKAL DAN TAKTIKAL PEMAIN BOLA KERANJANG UNIVERSITI DAN STRATEGI PEMULIHAN LATIHAN MINDA

Oleh

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Keletihan mental (MF) adalah keadaan psiko-biologi yang disebabkan oleh tempoh aktiviti kognitif yang menuntut yang berpanjangan. Kesan MF pada prestasi bola keranjang telah disiasat secara komprehensif dalam kesusasteraan. Walau bagaimanapun, kesan MF terhadap prestasi teknikal dan taktikal bola keranjang dan strategi pemulihan untuk mengatasi prestasi MF dan bola keranjang masih tidak jelas. Objektif kajian ini adalah untuk menyiasat kesan MF terhadap prestasi teknikal dan taktikal bola keranjang dan latihan kesedaran terhadap pemulihan MF, prestasi teknikal dan taktikal dalam kalangan pelajar universiti. Pendekatan ujian pra dan pasca dengan Percubaan Terkawal Rawak kluster (cRCT) telah digunakan dalam kajian ini. Saiz sampel dikira oleh pakej Perisian G*Power3.1. Memandangkan kesan reka bentuk, 54 pemain bola keranjang lelaki (n=18 setiap kumpulan) akhirnya direkrut dari tiga universiti dan berumur 18-24 tahun secara rawak ditugaskan ke dalam kumpulan kawalan (CG), kumpulan keletihan mental (MFG) dan kesedaran keletihan mental. kumpulan (MF-MG). Tugas Stroop 30 minit pertama kali digunakan untuk mendorong MF dalam MFG dan MF-MG. Kemudian, latihan kesedaran audio ringkas selama 30 minit telah digunakan dalam MF-MG. MF dan keadaan kesedaran diukur dengan skala analog visual (VAS) dan soal selidik kesedaran kesedaran lima aspek (FFMQ). Persembahan bola keranjang direkodkan dalam permainan sampingan kecil (SSG). Keputusan daripada Generalized Estimating Equations (GEE) menunjukkan bahawa MF secara signifikan mempengaruhi tahap perhatian dengan penurunan ketara dalam skor tumpuan perhatian (MD=3.61, $p<0.001$) dan anjakan perhatian (MD=3.11, $p<0.001$) bola keranjang pemain; skor kecekapan (MD=2.22, $p=0.006$), dengan penurunan ketara dalam bilangan mata (MD=2.28, $p<0.001$), matlamat lapangan dibuat (MD=0.94, $p<0.001$) dan peningkatan dalam bilangan lantunan (MD=-1.06, $p<0.001$); prestasi taktikal dengan penurunan ketara dalam bilangan pembalikan bola (BR)(MD=0.56, $p=0.030$), skrin atas bola (ONBS)(MD=1.50, $p<0.001$) dan peningkatan dalam penembusan menggelecek ke dalam kawasan utama (DPKA)(MD=-1.56, $p<0.001$); keadaan kesedaran dengan penurunan ketara dalam skor keadaan kesedaran (MD=8.39, $p<0.001$) membentuk ujian

pra hingga ujian pasca dalam MFG. Sebaliknya, latihan kesedaran mengatasi kesan MF pada skor tumpuan perhatian (MD=0.39, p=1.000) dan anjakan perhatian (MD=0.28, p=1.000); skor kecekapan (MD=-1.78, p p=0.083) termasuk bilangan mata (MD=-1.44, p=0.056), lantunan (MD=0.17, p=0.058) dan gol padang yang dibuat (MD=-0.56, p =0.001); prestasi taktikal termasuk BR (MD=0.33, p=1.000), ONBS (MD=-0.78, p=0.378) dan DPKA (MD=0.22, p=1.000); skor keadaan kesedaran (MD=-7.33, p<0.001) daripada ujian pra hingga ujian pasca dalam MF-MG. Kecuali daripada ujian pra hingga ujian pasca, hanya dalam ujian pasca, keputusan juga menunjukkan terdapat kemerosotan ketara MF pada skor tumpuan perhatian (MD=3.78, p<0.001) dan peralihan perhatian (MD=3.33, p=0.005); skor kecekapan (MD=2.94, p=0.017) termasuk mata (MD=2.50, p<0.001), bilangan lantunan (MD=-1.33, p<0.001) dan gol padang yang dibuat (MD=1.39, p<0.001) ; prestasi taktikal termasuk BR (MD=0.72, p=0.018), DPKA (MD=-1.94, p=0.022) dan skrin luar bola (OFFBS) (MD=1.00, p=0.025); skor keadaan kesedaran (MD=7.67, p=0.032) dalam MFG berbanding dengan CG. Sebaliknya, keputusan menunjukkan pemulihan latihan kesedaran pada skor tumpuan perhatian (MD=-3.61, p<0.001) dan anjakan perhatian (MD=-3.00, p=0.008); skor kecekapan (MD=-2.67, p=0.092) termasuk mata (MD=-3.06, p<0.001) dan bilangan gol padang yang dibuat (MD=-1.22, p<0.001); prestasi taktikal termasuk BR (MD=-0.78, p=0.013), DPKA (MD=2.39, p=0.004) ONBS (MD=-1.61, p=0.011) dan OFFBS (MD=-1.33, p<0.001); skor keadaan kesedaran (MD=-16.39, p<0.001) dalam MF-MG berbanding dengan MFG pada ujian pasca. Kesimpulannya, MF menjejaskan prestasi teknikal dan taktikal bola keranjang dengan ketara, dan latihan kesedaran adalah kaedah yang berkesan untuk mengatasi kesan negatif MF terhadap prestasi teknikal dan taktikal bola keranjang.

ACKNOWLEDGEMENTS

Over the courses of my researching and writing this thesis, I want to express my thanks to all those who gave helpd me.

First, I would like to express my gratitude to UPM. During the Covid-19, anything became really hard. Thanks for the opportunity and all the help from the university.

Afterwards, I would like to give my heartfelt thanks to my supervisor Prof Dr. Soh Kim Geok, for her invaluable instruction, engagement and inspiration. She is the most serious person I have ever seen. I still remember we discussed many details about revising articles until deep night. I know I could not have this achievement without her guidance. Her attitude to her word and students also inspires me work hard. I would also like to express my sincere gratitude to my committee member, Dr. Samsilah bt Roslan for her professional advice and guidance, to Dr Qian Shaowen, Wu Jianxi and Zhuqing helping me during the experimental process.

In addition, I wish to express my thanks to my family. My mother, father and sister always encourage me to persist in difficult times.

Finally, I want to thank all my affectionate classmates and friends. Especially, I want to express my gratitude to my senior Sun He. I have learned the serious attitude and persistent efforts in academic from him, and he also gives me a lot of guidance at any time. I believe I will help other juniors like him. During the several years study and the writing of this thesis, my gave me a lot of support and encouragement in their own way.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

MF	Mental Fatigue
MAC	mindfulness-acceptance-commitment approach
MAIC	Mindfulness-Acceptance-Insight-Commitment
PTS	Points
FGM	Field Goals Made
FGA	Field Goals Attempted
REB	Rebounds
AST	Assists
STL	Steals
BLK	Blocks
TO	Turnovers
EFF	Efficiency
BR	Ball Reversal
DPKA	Dribble Penetration into the Key Area
PE	Post Entry
ONBS	On-Ball Screen
OFFBS	Off-Ball Screen
HO	Hand Off
SSG	small-sided games
CG	control group
MFG	mental fatigue group
MF-MT	mental fatigue and mindfulness training group
VAS-MF	Visual Analogue Scale for Mental Fatigue
VAS-MO	Visual Analogue Scale for Mental Fatigue
ACS	Attention Control Scale

FFMQ	Five Facet Mindfulness Questionnaire
RPE	Rating Perception of Effort
SCS	Self-Control Scale
CSAI-2	Competitive State Anxiety Inventory-2
PANAS	Positive and Negative Affect Scale
ICC	intraclass correlation coefficient
GEE	Generalized Estimating Equations

CHAPTER 1

INTRODUCTION

1.1 Background

Modern athletic basketball competition has been deeply loved by people on a global scale, becoming one of the most popular sports (Qingyong & Zhengji, 2019). In China, through nearly 30 years of league practice and professional operation, the Chinese Basketball Association (CBA) has gradually developed and expanded (Yang et al., 2021). Especially in February 2017, after Yao Ming was elected chairman of the association, he carried out a drastic reform of the Basketball Association, "opening up" to run sports, and mobilizing the whole society to participate in basketball, and achieving remarkable results (Qingyong & Zhengji, 2019).

However, the development of basketball in China is not always going well. For instance, the Chinese men's basketball team lost to Poland and Venezuela in the 2019 Basketball World Cup at home, stopping in the top 16 (Xuang & Shusheng, 2021), and subsequently disqualified from the Tokyo Olympic Games. It is the first time the Chinese men's basketball team has missed the Olympic Games since 1984 (Yang et al., 2021). It is necessary to determine why Chinese basketball players cannot perform well. Prior studies analyzed the causes of failure and found that low shooting from outside, few rebounds, low shooting from free throws, and more turnovers were the main reason for technology (Yang et al., 2021). In addition, emotional public opinion was also a critical factor in psychology. Fans' ridicule catalyzes pressure, and fans' comments are the pressure catalyst of the Chinese men's basketball team.

1.1.1 Psychology, Mental Fatigue, and Basketball Performance

A psychological state is an important factor in sports performance. For instance, for some athletes, pressure situations and attentional disruptions can result in adverse effects on performance (Hill et al., 2017). Specifically, heightened anxiety levels can compromise an athlete's ability to concentrate on task-relevant information in the present moment (Beilock & Carr, 2002). Basketball performance is affected by several conditional, including motor skills, technical-tactical performance, and psychological factors, such as hand coordination, lower-body power, the ability to change direction, offensive and defensive agility, memory-retention, selective attention, prediction, reduced lower-body sidedness (Kioumourtzoglou et al., 1998; Spiteri et al., 2017). In basketball performance, a study reported that pressure negatively affected the quality of decisions for highly complex situations (Kinrade et al., 2015), and basketball players made worse decisions in high-criticality possessions (e.g., high stress) than those in low-criticality possessions (Bar-Eli & Tractinsky, 2000). During the pandemic of COVID-19, it is difficult for basketball athletes to continue training or competing as usual. The period of physical inactivity would negatively influence their physical ability and mental health (Lorenzo Calvo et al., 2021), such as anxiety, depression, and post-traumatic stress disorder (Mon et al., 2020).

Techniques and tactics actions play essential roles in basketball, especially now that the physical demand of the matches has significantly increased after the changes in the rules that occurred in the 2000s (Cormery et al., 2008). Such changes have occurred because of the specific demands of the games, with offensive, defensive and transition tactics, in which players use techniques and tactics actions to solve tasks (Cormery et al., 2008). The defensive (e.g., shooting, rebounding, passing, and dribbling) and offensive skills (e.g., blocking, stealing, and rebounding) of basketball have a strong influence on team success (Lamas et al., 2015). Basketball is non-deterministic, which can be modeled as a dynamic system with two opposing teams in offense and defense (Bourbousson et al., 2010; Gréhaigne & Godbout, 1995; Lamas et al., 2017). They organize behaviors to score or prevent opponent to score during offense and defense, respectively, and the offensive team tries to create space in the opponents' defensive system to obtain the opportunity. These behaviors always transform between offensive and defensive states (Bourbousson et al., 2010). By comparing the different game types (e.g., close, balanced, and unbalanced scores) and the outcome of game, the differences between winning and losing teams was investigated (Leite et al., 2009). The longer ball possessions and the more passes and points in different defensive systems determined the offensive success in close games (Ruano et al., 2006). On the other hand, the screen's orientation on the ball and the dribbler's actions after a screen were important for basketball success in this particular type of game. (Ruano et al., 2006). The defensive rebounds are the most significant factor to decide winning from losing.

In contrast, as for the unbalanced games, the defensive rebounds, assists, and 2-point field goals are different between losing teams and winning teams (Ruano et al., 2008). Study analyzed 306 regular and professional games. The results showed that the defensive rebounds, assists, accuracy in 3- point field goals and 3-point field goals dominated the winning. (García et al., 2013). However, there was different in 17 playoffs games, only the defensive rebounds determined the win (García et al., 2013). However, the psychological state has always influenced technical and tactical performance. In fierce competitions, athletes could not always perform well, especially the game results are significantly meaningful for them. In this case, their performance might be impaired by the higher pressure and cognitive burden, (Nieuwenhuys & Oudejans, 2012) which can interfere athletes' attention and induce anxiety. (Englert & Bertrams, 2012b; Oudejans et al., 2011). In this situation, self-control would be exerted to regulate their anxiety and attention (Baumeister et al., 2007; Englert, 2016; Englert & Bertrams, 2012a; Wilson et al., 2009). The process of exerting self-control can improve their execution of desired behaviors and help them focus on task-relevant actions leading to the improvement of performance (Baumeister et al., 2007; Englert, 2016). However, the excessive use of self-control exerting can cause the failure in efforts. Then, the ego depletion or mental fatigue (MF) would be induced (Baumeister et al., 2016).

Mental fatigue (MF) is a psycho-biological state caused by a prolonged period of demanding cognitive activity. There are a lot of aspects that were affected by MF in daily life, such as the decreased cognitive ability and acute feeling of tiredness (Boksem & Tops, 2008; Marcora et al., 2009; Van Cutsem et al., 2017). Recent studies aimed at investigating the effects of MF showed that MF harms athletic performance (Grgic et al., 2022; Habay et al., 2021; Pageaux & Lepers, 2018; Van Cutsem et al., 2017), such as the decision-making and response accuracy and speed in motor skills. MF also impairs the soccer, badminton, basketball, and cricket performance (Habay et al., 2021).

Although MF is a current research topic, as early as 20th century, the people researched the impacts of MF on physical performance.

1.1.2 Mindfulness Training as a Recovery Intervention

Many studies investigated mindfulness training in sports areas (Buhlmayer et al., 2017; Noetel et al., 2019), and they indicated that mindfulness training could decrease psychological stress leading athletes to more goal-oriented performance. On the other hand, the physiological and psychological surrogates improved significantly following mindfulness practice and sports performance. The strategy of mindfulness training could be considered a complementary training method for mental skills for athletes. In addition, Previous studies proved that mindfulness (or meditation) training could resist the adverse effects of MF. For instance, Friese et al., 2012 argued that the self-control could be improved by a brief mindfulness meditation under low resources condition (Friese et al., 2012). Yusainy and Lawrence (2015) showed that mentally fatigued partisans who received mindfulness induction behaved less aggressively than those without mindfulness induction. Mindfulness is rooted in Buddhism (Bodhi, 2011), and it is defined as the awareness that emerges from paying attention to objects on purpose, and without judging the unfolding of experience (Kabat-Zinn, 2003b). There are different types of mindfulness training, such as yoga or meditation (Bergomi et al., 2015). In successful mindfulness meditation, meditators do not judge or evaluating their current thoughts, feelings, and bodily sensations but they can experience them. (Baer et al., 2006).

Mindfulness has become the latest representative of cognitive behavioral therapy. Doctor Kabat Zinn is the first western scholar to introduce mindfulness to the discipline of psychotherapy, and he found mindfulness-based stress reduction (MBSR), based on which researchers created MMFT, and studies proved the MMFT can mitigate the attentional performance lapses and self-reported mind wandering. Afterward, other scholars found mindfulness-based cognitive therapy (MBCT), acceptance and commitment therapy (ACT) and dialectical behavior therapy (DBT). These therapies have been proven to have a good curative effect on eating disorders, drug abuse, personality disorders, anxiety disorders, and trauma (Si, 2014).

As early as 1985, Kabat-Zinn first used mindfulness in sports (Ludwig & Kabat-Zinn, 2008). He conducted a two-week to seven-month mindfulness training for yachtsmen at college and Olympic levels. The training content included general meditation in group and individual forms and pre-competition training. At present, the mindfulness-based training methods in sports psychology have included mindfulness-acceptance-commitment approach (MAC) and the mindfulness sports performance enhancement (MSPE) (Gardner & Moore, 2007). MSPE is a new psychological training method developed by Kaufman et al. (2009) (Kaufman et al., 2009) that can improve fluency state, sports performance, and psychological factors. In this method, athletes conduct consistent and regular mindfulness training to cultivate mindfulness skills under guidance, which urges them to achieve a mentality like flow experience to prepare for excellent behavioral performance. MAC is a well-developed and structured mindfulness

training method developed by Gardner and Moore (2004, 2005, 2007) (Gardner & Moore, 2007).

MAC training program not only elaborates on the two Zen concepts of "mindfulness" and "acceptance" but also puts forward the core viewpoint of "values" and distinguishes "emotion-driven behavior" and "value-driven behavior." Gardner and Moore believe that MAC training can help guide athletes to clarify their values and use the concepts of "mindfulness" and "acceptance" to invest more in "value-driven behavior" (Zhang et al., 2012). However, without clear values, athletes can directly invest in "value-driven behavior." Gangyan Si believed that although MAC has put forward its core concept of "value," which aims to help athletes find appropriate values and develop "value-driven behavior" to solve the problem of behavior input, in essence, it is because it highlights an individualistic value (Si et al., 2011). Value-driven behavior also highlights self and does not solve the relationship between self and society. It is also challenging to integrate oneself into the environment and process. For example, the core value of athletes is the pursuit of excellence, which encountered various problems and confusion in this process. For example, a person is very clear about their goals and abilities but is too nervous about letting go under pressure. They have a strong enterprising spirit or personality but encounter the unique system situation of their country and produce inner conflict. Therefore, the psychological training methods that can help athletes grow must conform to their social and cultural conditions. Based on his years of working experience in front-line sports psychological training and previous research results, Gangyan Si introduced another Zen thought - "consciousness." Consciousness is not the persistence of thinking but the awareness of new wisdom in life. When a person cannot be persistent, his beliefs or ideas about the importance of things in life will also have a new understanding. Instead of being stubborn in unchanging beliefs or ideas, he can show flexibility in thinking about beliefs or ideas under different space-time conditions. Use values that are different from the past and more integrated with society to look at sports career and life development, and look at interpersonal and social relations from a new perspective. It mainly involves the views and responses to the results of the competition and various problems that may occur in sports training to better participate in sports competition and achieve physical health, mental health, and harmony. It is from the creative understanding of things or a new perspective. The basis on the MAC training program proposed by Gardner and Moore. Gangyan Si and his partners developed the training program of Mindfulness-Acceptance-Insight-Commitment (MAIC) by integrating the local concepts of "social orientation values" and "awareness" Based on the training procedure of MAIC, the mindfulness training course includes seven parts: preparation, mindfulness, self-centeredness, acceptance, values and awareness, input, and comprehensive training (Gangyan; & Danran, 2015).

Under Chinese social and cultural conditions, it is inappropriate to copy western theories and methods completely when carrying out psychological training for local athletes. The emergence of the MAC intervention method undoubtedly provides a new perspective for applying local sports psychology. Researchers hope to truly serve athletes with the developed content, methods, and concepts in MAC localization in China (Gangyan; & Danran, 2015).

Finally, the implementation of mindfulness training has some barriers, such as the long duration and that usually the mindfulness processes need highly trained therapists and many settings (Gardner & Moore, 2004; Pineau et al., 2014). For the feasibility of mindfulness training, this study used the brief mindfulness intervention. The effectiveness of brief mindfulness intervention was proved in previous studies (Perry, J. E. et al., 2017; Shaabani et al., 2020; Stocker et al., 2019; Wang et al., 2017; Yusainy & Lawrence, 2015b).

1.2 Problem Statement

Since Yao Ming became the chairman of the China Basketball Association in 2017, Chinese basketball has ushered in a new period of comprehensive reform and rapid development (Yang et al., 2021). However, The Chinese men's basketball team lost to Poland in the 2019 Basketball World Cup at home, losing to Venezuela and stopping in the last 16. Subsequently, many topics surrounding the failure of the Chinese men's basketball team exploded quickly on several media platforms and quickly occupied the hot search list of media, and the network was "in a mess." On the other hand, on 2 June 2021, the Chinese team lost to the Greek team 80-105 in the men's basketball Olympic disqualification. After two consecutive defeats, the Chinese team lost its qualification to compete in the Tokyo Olympic Games. It is the first time the Chinese men's basketball team has missed the Olympic Games since 1984 (Yang et al., 2021). The development of Chinese basketball has been impacted strongly.

By analyzing the data, studies indicated the low free throws percentage and three-point shots, a high percentage of turnover, and emotional ups and downs in the face of high pressure were the main problems of the Chinese men's basketball teams (Yang et al., 2021). MF is a possible factor that impacts their basketball performance. For instance, in the fierce game, Chinese players need to exert the strength of self-control to mitigate the increase of anxiety and nervous. In this process the overuse of self-control strength would induce MF. Research reported that MF could attenuate basketball performance like a free throw and three-point shots (Bahrami et al., 2020; Filipas et al., 2021; López et al., 2017; Moreira, Alexandre, Aoki, Marcelo Saldanha, et al., 2018; Shaabani et al., 2020) and cognitive performance (e.g., decision making) (Hepler & Kovacs, 2017), but there is not any study examanizing the impacts of MF on tactical performance. Therefore, the effecs of MF on tactical performance should be investigated.

On the other hand, it is necessary to find a suitable method to help basketball players recover from MF. It has been proven that mindfulness training could recover peoples' psychological performance (e.g., attention and concentration, aggression, mind wandering) (Axelsen et al., 2020; Friese et al., 2012; Yusainy & Lawrence, 2015a) and sport-related performance (e.g., plank exercise, basketball free throw) (Shaabani et al., 2020; Stocker et al., 2018) under MF. However, whether mindfulness recovers the technical-tactical performance in basketball under MF is unclear.

It is essential to study the impacts of MF on basketball performance and mindfulness training on the recovery of MF and performance. It is also meant to find the mechanism of that. The psychological model of exercise performance suggests that MF can impair

physical (endurance) performance by increasing the perceived exertion (Marcora et al., 2009). Then, technical and tactical performance belong to motor skills (Badin et al., 2016; Diniz et al., 2021) and decision-making (cognition) (Elferink-Gemser et al., 2010; Mouchet, 2005), respectively. Therefore, how MF affects basketball technical-tactical performance is unclear. On the other hand, it has been proven that MF can attenuate the technical (Boksem et al., 2005) and tactical performance (Diniz et al., 2021; Smith, M. R. et al., 2016) by decreasing attention levels, but the effects in basketball areas are unclear. Therefore, whether the MF can affect basketball technical-tactical performance by decreasing attention levels should be investigated.

In addition, another model called the model of mindfulness and de-automatization illustrates that mindfulness can recover attention leading to the recovery of self-control strength (Kang et al., 2012), which also can recover the MF. Therefore, this study combined the two models to find the effects of MF on basketball performance and the effects of the recovery method on MF and basketball performance.

As for the population, many studies researched the impacts of MF on athletes' or amateurs' basketball performance (Filipas et al., 2021; Moreira, Alexandre, Aoki, Marcelo Saldanha, et al., 2018; Shaabani et al., 2020), but just one study focused on undergraduate students (Hepler & Kovacs, 2017). A study argued that 73% of student respondents in university describe having at least one experience of a mental health crisis ((NAMI), 2012). The study also reported that it is a great challenge for managers to improve the prevalence of student anxiety and provide supportive services to ensure their mental health takes priority ((CCMH), 2017). Therefore, the impacts of MF on university basketball players' technical and tactical performance and the recovery strategy of mindfulness training should be investigated.

1.3 Research Objectives

1.3.1 General Objective

The current study aims to examine the effects of MF on basketball players' attention, technical performance, tactical performance, and mindfulness state, and the recovery strategy of mindfulness training to attention, technical performance, tactical performance, and mindfulness state.

1.3.2 Specific Objectives

Based on the general objective, the specific objectives were:

1. To investigate the effects of MF and mindfulness training on the attention of Basketball players.
2. To investigate the effects of MF and mindfulness training on basketball players' technical performance.

3. To investigate the effects of MF and mindfulness training on basketball players' tactical performance.
4. To investigate the effects of MF and mindfulness training on basketball players' mindfulness state.

1.4 Hypotheses of Research

1.4.1 General Hypothesis

The main hypothesis of current study is to evaluate whether the MF significantly affects basketball players' attention, technical performance, tactical performance, and mindfulness states and whether mindfulness training can recover attention, technical performance, tactical performance, and mindfulness state under MF.

1.4.2 Specific Hypothesis

The specific null hypothesis associated with the first objective is:

H_{01}: There is no significant effects of MF on the attention of basketball players.

H_{02}: There are no significant effects of mindfulness training on attention.

The specific null hypotheses associated with the second objective are:

H_{03}: There is no significant effects of MF on basketball players' efficiency.

H_{04}: There is no significant effects of mindfulness training on basketball players' efficiency.

The specific null hypotheses associated with the third objective are:

H_{05}: There is no significant effects of MF on basketball players' tactical performance.

H_{06}: There is no significant effects of mindfulness training on basketball players' tactical performance.

The specific null hypotheses associated with the fourth objective are:

H_{07}: There is no significant effects of MF on basketball players' mindfulness state.

H_{08}: There is no significant effects of mindfulness training on basketball players' mindfulness state.

1.5 Significance of Study

1.5.1 Theoretical Significance

The strength model of self-control is used in the present study to detail the MF effects. In this model, physical (endurance) performance was impaired by MF with the increase of perception of effort (Marcora et al., 2009). Recently, He Sun et al. (2022) improved this model by adding attention as the third factor to explain the impairment of MF on soccer decision-making performance (Sun, Soh, Roslan, Wazir, et al., 2022). Basketball technical and tactical performance belong to motor skills (Badin et al., 2016; Diniz et al., 2021) and decision-making (cognition) (Elferink-Gemser et al., 2010; Mouchet, 2005), respectively. Whether the MF can impair the technical and tactical performance by decreasing the attention level in basketball is not clear. Therefore, this study advanced our understanding of whether the MF can affect basketball technical and tactical performance by attenuating the attention level.

In addition, more and more evidence has suggested that mindfulness training has some common mechanisms with self-control. It has been shown that mindfulness training can improve attention regulation (Hodgins & Adair, 2010; Jha, A. P. et al., 2007) and emotion regulation (Brown & Ryan, 2003), which play the key rule in self-control processes (Baumeister et al., 1994). Friese et al. (2012) indicated that mindfulness training was a practical approach to improving self-control strength (Friese et al., 2012), leading to recovering of MF (Englert, 2016). Mindfulness training can improve MF, and basketball technical performance like free throw under MF (Shaabani et al., 2020). However, it has not been proven whether mindfulness training can recover other basketball technical performances (e.g., the number of rebounds, assists) under MF, and most importantly, there is no evidence of the influences of mindfulness intervention on basketball tactical performance. Therefore, this study combined the Model of Mindfulness and De-Automatization and the strength model of self-control to advance our understanding that whether the mindfulness training can improve the basketball technical and tactical performance under MF.

1.5.2 Practical Significance

First, the present study has a practical contribution to the basketball team and coach. Previous studies proved mindfulness training could recover psychology (e.g., attention and concentration, aggression, mind wandering) and sport-related performance (e.g., plank exercise, basketball free throw). But none of the study has researched the impacts of mindfulness training on basketball technical-tactical performance under MF. Therefore, this study provided a specific 30 minute audio mindfulness training for basketball players to recover from MF.

On the other hand, this study also contributes psychology of sports. Except for basketball players, other sports such as succor, handball, and swimming also have the problem of MF (Kunrath et al., 2020; Macedo Penna, Campos, et al., 2017; Macedo Penna, Wanner,

et al., 2017). Therefore, other sports can use this audio mindfulness training as a recovery strategy.

1.6 Limitations of Study

The study was limited in the following aspects:

The Stroop task used to induce MF is not sport-specific. Because no sport-specific depletion task has ever been identified, the researcher chose the Stroop task because it was used in a self-control study successfully (Hagger et al., 2010). Nevertheless, inducing MF is necessary for the purpose for investigating the effects of MF on subsequent performance. Some studies reported that depleting cognitive tasks (e.g., Stroop task) disrupts subsequent physical function, which fits the purpose of this study (Bray et al., 2011; Englert & Wolff, 2014; McEwan et al., 2013). In addition, cognitive demands like the reaction capability of Stroop tasks are also needed in basketball games (Scanlan et al., 2014). Therefore, the Stroop task is not sports-related and was used in this study.

MF can affect technical performance (motor skills) by impairing monitoring and adjustment (Lorist et al., 2005), attention (Boksem et al., 2005), and anticipant (Lorist, M. et al., 2000). Furthermore, decreased attentional levels (Diniz et al., 2021; Smith, M. R. et al., 2016) and the efficiency of information processing ((Linden et al., 2003)) have influenced tactical performance (decision-making). Attention is the factor to affect both technical and tactical performance. In addition, a study proved that decreased attention could be the third factor besides perceived exertion and motivation to explain the negative impacts of MF on motor skill (decision-making) in soccer (Sun, Soh, Roslan, Wazir, et al., 2022). Hence, in current study, the researcher investigated the impacts of MF on attention to affect basketball technical and tactical performance. For other variables, like anticipant and the efficiency of information processing, the evidence that can attenuate both technical and tactical performance is insufficient. Therefore, further study should pay attention to that.

1.7 Delimitation of Study

The study was delimited in the following aspects:

The participants in this study were from universities with limited basketball experience. Therefore, it is impossible to determine how MF would affect the technical-tactical performance of highly skilled athletes. The results may not apply to athletes with different levels or non-athletic populations.

On the other hand, this study just investigated the mindfulness training on the recovery of basketball performance in 3vs3 SGS games, but for the 5vs5 official basketball game, which lasts longer (40 min in FIBA, 48 in NBA), the recovery effect is not apparent. However, recently, 3vs3 basketball has become more and more popular. This new sport was included in Olympic Program in 2017 (Conte et al., 2019). Considering the 3vs3

basketball is a relatively new port, not many studies are investigating it. For instance, Conteal et al. (2019) found that free throws, turnovers, and recovered balls were the most discriminatory variables between losing teams and winning teams in 3vs3 basketball games (Conte et al., 2019). Willberg et al. (2022) reported that in a 3vs3 basketball game, players are required to perform constant high-speed inertial movements, which result in more jumps, distance covered at high-speed thresholds, accelerations, and decelerations (Willberg et al., 2022).

1.8 Definition of Terms

1.8.1 Mental Fatigue

Conceptual definition: MF is a psycho-biological state caused by a prolonged period of demanding cognitive activity. There are many aspects that were affected by MF in daily life, such as the decreased cognitive ability and acute feeling of tiredness (Boksem & Tops, 2008; Marcora et al., 2009; Van Cutsem et al., 2017).

Operational definition: In this study, MF is a state of acute rising in the subjective rating of fatigue. A 30 min modified incongruent Stroop task was used to induce MF (Rozand et al., 2014; Smith et al., 2015). Like playing a basketball game, the participants need to sustain attention and inhibition control during the Stroop task (Rauch & Schmitt, 2009). When the sustained attention and inhibition were exhausted by the Stroop task, they were mentally fatigued. On the other hand, the MF was measured by the visual analog scale (100 mm).

1.8.2 Basketball Technical and Tactical Performance

Conceptual definition: Basketball technical performance means the particular action done to achieve the goals of basketball (Conte et al., 2018; Lan, 2001). Usually, technical performance is divided into a defensive (e.g., shooting, rebounding, passing, and dribbling) and offensive skills (e.g., blocking, stealing, and rebounding) (Lamas et al., 2015). Clemente et al. (2017) assessed the technical performance by the indicator of the successful shot, pass, neutral ball, conquered ball, lost ball and received ball (Clemente et al., 2017).

Basketball tactics can be divided in to offensive and defensive tactics, such screen, cut and slide through. Tactics can guide basketball players' skills and help them cooperate in game.(Lan, 2001). Usually, two or three offensive players can use some basic tactics in basketball to attack opponents' basket, such as cover cooperation, pass-cut cooperation and sudden point cooperation (Hua & Liu, 2021). Daniel et al. (2017) analyzed the basketball tactical performance by the action of defense, offense, defense transition, and offense transition (Daniel et al., 2017).

Operational definition: The following technical statistics were collected across all played games: points (PTS), blocks (BLK), steals (STL), field goals made (FGM), rebounds (REB), assists (AST), field goals attempted (FGA), turnovers (TO). The following formula was used to determine the player's efficiency: (PTS + REB + AST + STL + BLK − ((FGA – FGM + TO)). The following tactical statistic was collected: dribble penetration into the key area (DPKA), off-ball screen (OFFBS), ball reversal (BR), on-ball screen (ONBS), handoff (HO) and post entry (PE).

1.8.3 Mindfulness Intervention

Conceptual definition: Mindfulness is the awareness that emerges from paying attention to objects on purpose and without judging the unfolding of experience (Creswell, 2017; Kabat-Zinn, 2003a). Our daily life experience is highly contrasted with this process of present-moment experience, like the running on automatic pilot (Bargh & Chartrand, 1999), minds wander (Creswell, 2017; Killingsworth & Gilbert, 2010) and suppressing unwanted experiences (Kang et al., 2012). Mindfulness training can foster more awareness and significant attention of present moment experience (Creswell, 2017).

The mindfulness-based stress reduction (MBSR) is the one of the most popular mindfulness intervention (Kabat-Zinn, 1982). On the other hand, MBSR stimulated the development of other mindfulness interventions, such as mindfulness-acceptance-commitment approach (MAC) (Gardner & Moore, 2007), mindfulness-based cognitive therapy (MBCT) (Teasdale et al., 2000) and mindfulness-based relapse prevention (MBRP) (Bowen et al., 2014).

Operational definition: In this study, the mindfulness intervention was a 30-minute audio mindfulness training based on the MAIC training program developed by Gangyan Si. He and his partners developed the training program of MAIC based on the MAC training program (Gardner & Moore, 2007) by integrating the local concepts of "social orientation values" and "awareness." Based on the training procedure of MAIC, the mindfulness training course includes seven parts: preparation, mindfulness, self-centeredness, acceptance, values and awareness, input and comprehensive training (Gangyan; & Danran, 2015). The material for mindfulness intervention was from the book *Athlete mindfulness training manual* (Si, 2014).

1.8.4 Basketball Players

Conceptual definition: basketball players are people who play basketball. Basketball players can play various positions, such as center, power forward, small forward, shooting guard and point guard (Griffiths, 2010).

Operational definition: The male basketball players who are 18 to 24 years old, have more than 30 months of basketball training experience in university, and at least have twice basketball classes a week. In addition, they also have literacy courses at university.

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