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Pre-service Routines, Mental Toughness and Performance Enhancement of Young Tennis Athletes

Abstract

Some common performance enhancement strategies used by tennis players are related to a pre-service mental preparation routine. This study provides an insight on the efficacy of the implementation of mental routines on performance of young tennis players (aged between 11 and 14-years old). Specifically, we compared several performance indicators before and after the intervention, and when players performed *vs* when they did not perform the mental routines. We also tested whether mental toughness was a good predictor of performance, using behavioral measures to assess both mental toughness and performance. The results revealed: (1) a positive impact of the intervention program on performance efficacy; (2) athletes won more service games after the intervention program; and (3) mental toughness, explained by pre-service routines and players' ability to positively manage errors, was a good predictor of players' overall performance.

Keywords: Mental Routines; Pre-performance routines; Psychological Skills Training

Introduction

Mental Training Programs (MTP) have been frequently used by sport psychologists to improve athletes' skills and, consequently, their performance. Previous research has already established the positive impact of MTPs on performance in different sports (e.g., Bar-Eli & Blumenstein, 2005; Wolframm & Micklewright, 2011; Zetou, Vernadakis, Bebetsos, & Makraki, 2012). In tennis, Mamassis and Doganis (2004) investigated the impact of a season-long MTP by comparing two elite junior players who engaged in the mental training with four other players who received the same amount of tennis practice. They found that athletes who received the mental training experienced an increase in performance and self-confidence. Moreover, those who were not part of the program were less able to adjust themselves to the intensity of somatic and cognitive anxiety experienced during competition.

MTPs involve several skills, such as goal setting, positive thinking and self-talk, arousal regulation techniques, imagery, concentration and pre-performance routines (cf. Weinberg & Gould, 2015 for a review). In the present work, we conducted an intervention to teach young tennis players to use pre-performance routines, defined as "a sequence of task-relevant thoughts and action which an athlete engages in systematically prior to his or her performance of a specific sports skill" (Moran, 1996; p. 177). It is clear from the definition that both cognitive and behavioral processes are key in the preparation to the successful execution of a shot, and consequently, to performance.

Previous research has shown the benefit of using cognitive-behavioral strategies preceding the execution of motor skills in sport (e.g. Boutcher & Crews, 1987; Lobmeyer & Wasserman, 1986). There are different pre-performance mental strategies that can facilitate the execution of motor skills, such as relaxation, self-talk, imagery,

attentional focus, among others (cf. Burton, Pickering, Weinberg, Yukelson, & Weigand, 2010; Cohn, Rotella, & Lloyd, 1990; Valentzas, Heinen, Tenenbaum, & Schack, 2010). The combination of cognitive and behavioral strategies preceding the execution of motor skills are known as pre-performance routines, and they include both covert (cognitive) and overt (behavioral) processes (Cohn et al., 1990). These routines help athletes to achieve an appropriate psychological and physiological state prior to execution (Jackson & Baker, 2001), and to maintain a high level of performance even when facing distractions (Boutcher, 1992; Jackson & Baker, 2001; Lobmeyer & Wasserman, 1986).

Therefore, the impact of pre-performance routines on performance have been studied in several sports, such as basketball, volleyball, rugby, and golf, among others (e.g. Cohn et al., 1990; Cotterill, 2008; Czech, Ploszay, & Burke, 2004; Gooding & Gardner, 2009; Jackson & Baker, 2001; Lobmeyer & Wasserman, 1986; Mesagno, Marchant, & Morris, 2008; Valentzas & Heinen, 2011; cf. Cotterill, 2010 for a review). In tennis, one of the most common pre-performance routine used to enhance performance is the pre-service mental preparation routine (cf. Defrancesco & Burke, 1997; Lauer, Gould, Lubbers, & Kovacs, 2010; Mathers, 2016). Pre-service routine has been found to mitigate the negative impact of pressure on performance on tennis players' who experience anxiety under pressure situations (cf. Lautenbach, Laborde, Mesagno, Lobinger, Achtzehn, & Arimond, 2015).

The pre-service routine (both in first and second serve) is appropriate in tennis because this shot is not directly influenced by the opponent, and, therefore, the athlete performing the serve is in control; and the athlete has the time to execute all elements of the routine (Lautenbach et al., 2015). In the present study, we developed a cognitive-behavioral intervention to increase the use of a pre-service routine, aiming to study its

impact on performance. The pre-service routine, individualized for each player, included both overt and covert dimensions, and its impact on performance was assessed by using objective indicators. This approach has been less used in the literature to study the impact of mental training on tennis players' performance, despite the importance of players being able to respond positively to any failures, obstacles or setbacks that might arise in order to be successful (cf. Galli & Gonzalez, 2015). Indeed, this ability to remain focused and in control when facing adversity and under pressure has been broadly called mental toughness (Connaughton, Wadey, Hanton, & Jones, 2008; Madrigal, Hamill, & Gill, 2013; Weinberg, Freysinger, Mellano, & Brookhouse, 2016). Thus, if this is the case, then it is important to provide an understanding of the relationship between mental training, and particularly pre-service routines, and mental toughness behaviors, as well as their implications on performance. In our study, we address this topic of research, establishing that our intervention enhances tennis players' performance, namely by increasing their percentage of first-serves, decreasing the number of double-faults, and by increasing players' performance efficacy. We expect:

H1. (a) Higher percentage of first-serves and (b) less double-faults after the intervention.

H2. Participants to win more service games after the intervention.

H3. (a) Participants to improve their performance efficacy after the intervention, (b) especially when they performed the pre-service routine.

Mental toughness

Mental toughness has been consistently presented in the literature as one of the most important contributors to enhance sports performance (e.g. Golby & Sheard, 2004; Gould, Dieffenbach, & Moffett, 2002; Gucciardi & Gordon, 2009; Jones, Hanton, & Connaughton, 2002). Jones and colleagues (2002) defined mental toughness as "the

natural or developed psychological edge that enables you to generally cope better than your opponents with the many demands that sport places on a performer. Specifically, be more consistent and better than your opponents in remaining determined, focused, confident, and in control under pressure" (p. 209).

This definition is consistent with the idea that mental toughness encompasses a set of attributions, namely self-confidence, visualization and imagery control, positive energy, motivation, attitude control, negative energy control (e.g., being able to cope with anger and frustration), and attention control (focus) (Loehr, 1986; cf. also Holland, Woodcock, Cumming, & Duda, 2010). The precise composition of mental toughness is still debatable; however, for the purpose of this study, mental toughness, due to the variation of its properties over time and across situations, has been defined as a state-like psychological resource that helps athletes to display and maintain goal-directed behavior despite of adversities (Bell, Hardy, & Beattie, 2013; Ponnusamy, Lines, Zhang, & Gucciardi, 2018). Recent research has provided evidence that supports the idea that mental toughness is positively associated with an increase in high performance (e.g., Mahoney, Gucciardi, Ntoumanis, & Mallett, 2014; cf. Cowden, 2017 for a review).

Ponnusamy and colleagues (2018) have recently conducted a study with 285 elite athletes and concluded that a higher use of psychological skills and techniques was associated with higher levels of mental toughness. In tennis, mental toughness is particularly important, as players face several stages during competition that require sustained determination and concentration (Cowden, Fuller, & Anshel, 2014), remaining positive when facing failure and setbacks (Galli & Gonzalez, 2015).

The debate regarding mental toughness definition has, consequently, translated to difficulties in how to measure this concept. In this research, we aim to take a step

further into this discussion by taking a different approach and using observed behavior to measure mental toughness. Besides helping to deal with the different biases associated with self-reported instruments (cf. Hardy, Bell, & Beattie, 2014), behavioral measures for both mental toughness and performance may help researchers to disentangle the process of being mentally tough from its antecedents and outcomes (f. Hardy et al., 2014).

Gucciardi and colleagues (2015) argued that "the consistent demonstration of salient behaviors across various situations or time points" (p. 68) is one way of operationalizing the reputation of one being mentally tough. They conducted a study in which tennis coaches and players were asked to generate mentally tough behaviors. Their results showed that working hard no matter which setbacks are encountered, perform the best of their ability no matter how the athlete is feeling, refusing to give up when things get tough, fighting for every point and being a good decision-maker were some of behaviors indicated by coaches and players that reflect mental toughness (cf. Gucciardi et al., 2015). Considering the impact of pre-performance routines on helping players to remain positive and deal positively with errors, we argue that these routines will help tennis players to maintain their focus on task-relevant cues and, therefore, facilitate a state of mental toughness which, in turn, leads to a better performance. Thus, we expect:

H4. Pre-service routines and error management to be good indicators of mental toughness and, in turn, mental toughness to predict players' performance (first-serve and double-faults' percentages, as well as their performance efficacy).

To the best of our knowledge, this is the first time that these specific relationships are tested using behavioral measures, even though mental training and

mental toughness represent major topics of sports psychology literature (Jones et al., 2002; Weinberg & Gould, 2015).

Method

Participants

The study included 11 tennis players (10 males, 1 female) aged (at the performance baseline stage) between 11 and 14 years-old (M = 12.09, SD = 1.22). Athletes were amateur players starting to compete in their age-group (U12 and U14) national competitions. Their tennis experience was ranged between 3 and 8 years (M = 4.91, SD = 1.70).

Procedure & Design of the Study

A local tennis club was approached and agreed to participate in the study. A group of young players was selected to receive the intervention program based on their availability, at least three years of experience, and engage in competitive tournaments. Once informed consent from both players and parents was obtained, data was collected for posterior comparison. The procedure involved two stages: Performance baseline and Intervention phases.

Performance baseline. Prior to the intervention, 39 service-games were recorded. The percentage of first-serves, double-faults, and efficacy was measured. Their performance (won *vs* lost) was also registered. After measuring their baseline scores, all players received the intervention.

Intervention. It was a cognitive-behavioral intervention (cf. D'Zurilla, 1988; Gomes, 2010) designed to increase players' adherence to a pre-service mental and behavioral routine. During ten 1-2 hour sessions (on or off court, depending if the cognitive or the behavioral components were the focus of the session), the aim was to develop a systematic behavioral and cognitive preparation prior to serve, with one of the researchers working closely with the players to individualize and automatize the mental

and behavioral routine. The cognitive and behavioral dimensions were practiced simultaneously. The cognitive component of the routine was introduced at the early stage of the intervention, in which players were instructed and taught to analyze the game, make a strong decision about the type and direction of serve, to commit with that decision, and to have a positive self-talk before the point (cf. Cotterill, Sanders, & Collins, 2010 for more information on pre-performance routine development). The players were also instructed to restart the routine every time distractions occurred during the routine[1]. The behavioral component consisted on teaching players the importance and how to assess good posture, positive body language, and physical regulation (through breathing exercises). During training sessions, and when necessary, corrections on athlete's posture, body language, and physical regulation were made to allow them to consistently perform the pre-service routine.

After the intervention, 45 service-games were analyzed, and the indicators registered in the baseline phase were compared. The same indicators were also analyzed considering if players performed or not the routine. Therefore, a total of 84 service games (39 before the intervention; 45 after the intervention) were observed and coded during practice-matches.

Measures

Performance. Using a coding sheet[2], each observation (service game) was coded on the following parameters: (1) *first-serve* (number of valid first-serves performed); (2) *double-faults* (number of double-faults); (3) *performance efficacy* (number of points won in the service game); (4) *success* (if the athlete won *vs* lost the service-game).

[1] The routines were developed by both authors, but only the first author worked directly with the athletes to individualize and practice the routine, in order to ensure consistency.
[2] Coding sheet available on request

Because, in tennis, each service game is composed by a flexible number of points, the first three scores mentioned above were transformed into percentages.

Mental toughness. Mental toughness was assessed by observing players' behavior during and between points – this was done by the first author of the paper, who has previous experience as a tennis player. Specifically, two indicators were used: (1) the observed routines (number of times the routine was visibly performed divided by the number of points –percentage of observed routines), particularly we looked at the posture, body language prior to the serve, and physical regulation; and (2) error management (number of times players displayed negative body language after an error divided by the number of points in which an error occurred – percentage of error management), we looked for behaviors that indicated a negative reaction to the error, such as head pointed down, slumped shoulders, cursing. Therefore, we expected mental toughness to be reflected on higher percentage of routine and lower percentage of (negative) error management.

Results

Data analysis approach

In order to assess if the sample followed a normal distribution, skewness and kurtosis for all variables were assessed. Once no variable presented a skewness higher than |3| ($0.03 > s < 2.54$) nor a kurtosis higher than |10| ($0.09 > k < 6.31$), it was assumed that no severe deviations from a normal distribution were present in the sample and, therefore, parametric tests could be performed (cf. Kline, 2005). Means, standard deviations, and correlations for each dependent variable are displayed in Table 1.

Table 1.

Means (standard deviations) and correlation Matrix for all measures.

		1.	2.	3.	4.	5.
1.	First-serve (%)	46.24(19.88)				
2.	Double-faults (%)	-.511***	16.59(18.19)			
3.	Performance efficacy (%)	.272*	-.469***	42.71(25.31)		
4.	Pre-service routine (%)	.335*	-.379**	.278†	72.03(27.91)	
5.	Mental toughness	.291*	-.431**	.446**	.675***	2.93(1.23)

N = 84 (*N* = 45 for pre-service routine and mental toughness)

† *p* = .064, *$p < .05$, ** $p < .01$, ***$p < .001$

Two different types of comparisons were conducted: (1) to evaluate the efficacy of the intervention's program, 84 service games performed before (*n* = 39) or after (*n* = 45) were compared using independent-sample t-tests[3] (hypotheses 1a, 1b, and 3a). In order to ensure that the data is fully comparable, the data presented in this section refers to players' performance during training sessions; (2) to evaluate the impact of the mental routines on athlete's performance, the service games after the intervention were analyzed, comparing athlete's efficacy when performing (*vs* not performing) the mental routines within each service game. Paired-sample t-tests were used (hypotheses 1a and 3b).

To test the idea that mental toughness (assessed by players' performance of mental routines and by their ability to positively manage errors) have a positive impact on the different performance indicators, we tested model below using AMOS software (cf. Figure 1; H4). The model fit to the data was evaluated by using the chi-square statistic (χ^2), the confirmatory fit index (CFI), and the root-mean-square error of

[3] The number of service-games per participant per condition (before *vs* after) did not significantly differ, $\chi 2(10, N = 84) = 14.28$, $p = .161$.

approximation (RMSEA). A good fit is reflected by CFI values greater than .95 and RMSEA values inferior to .06 (cf. Hu & Bentler, 1999).

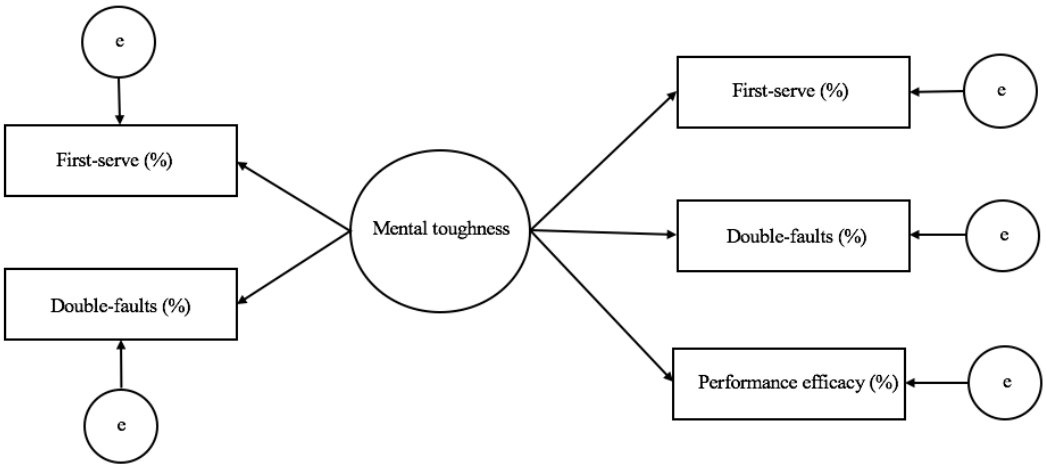

Figure 1. Structural model for the relationship between mental toughness and performance indicators (first-serve, double-faults, and performance efficacy). The circles represent factors (latent variables), and rectangles represent indicators (observed variables), whilst the arrows represent direct paths and the *e* represents the measurement errors.

First-serve percentage

Athlete's percentage of first-serves did not significantly differ between pre-intervention (M = 44.84, SD = 21.52) and post-intervention (M = 47.45, SD = 18.50), t (82) = -0.60, p = .552. Comparing to the overall first-serve performance, performing the routine (M = 51.49, SD = 25.83) did not significantly increase their overall percentage of first-serves (M = 47.39, SD = 18.71), t (43) = 1.51, p = .138. Although the results seem to go in the proposed direction, this is not consistent with our hypothesis (H1a). However, their percentage of first-serves was significantly higher when comparing if the routine was performed (M = 79.52, SD = 33.31) versus not performed

(M = 20.48, SD = 33.31), t (43) = 5.88, p < .001, g = 1.74. Thus, H1a was partially supported.

Double-faults percentage

Athlete's performed significantly less double-faults after the intervention (M = 11.98, SD = 13.75) than before (M = 21.91, SD = 21.20), t (82) = 2.50, p = .015, g = 0.56. Therefore, H1b was supported.

Success

Players' win-loss score on service games was 8-24 before the intervention, and 25-20 after the intervention. A Chi-square analysis on the amount of service games won/lost before and after the intervention revealed that players win significantly more service games in the post-intervention, $\chi^2(1, N = 77) = 7.13$, p = .008. Thus, H2 was supported.

Performance efficacy

Players won more points in their service games after the intervention (M = 47.72, SD = 24.61) than before (M = 36.92, SD = 25.16), t (82) = 1.99, p = .050, g = 0.43; therefore, H3a was supported. When comparing their efficacy after the intervention, they also won more points when they performed the routine (M = 40.20, SD = 24.56) when compared to when they did not perform it (M = 7.53, SD = 15.13), t (44) = 6.74, p < .001, g = 0.46. Thus, H3b was supported.

Model

The proposed model presents a great fit to the data, $\chi^2(5, n = 44) = 2.16$, p = .827; CFI = 1.00, RMSEA = .001, p (RMSEA ≤ .05) = .857, 90% IC [0.000, 0.126]; AIC = 22.16, BCC = 25.40, MECVI = 0.591. The model explains 29% of variance of players' first-serve percentage, 64% of double-faults percentage, and 37% of their performance efficacy. Supporting our hypothesis (cf. Table 2), players' mental

toughness was predicted by performance of pre-service routines and by less negative reactions to errors (error management). In turn, the stronger their mental toughness, the higher their first-serve percentage and their performance efficacy, and the lower their double-faults percentage.

Table 2. Parameters' estimates for the proposed model.

	B	*SE*	*p*	*b*
Observed routines (%) -> Mental toughness	14.06	4.60	.002	.504
Error management (%) -> Mental toughness	-13.90	6.33	.028	-.371
Mental toughness -> First-serve (%)	10.01	3.03	< .001	.541
Mental toughness -> Double-faults (%)	-10.88	2.21	< .001	-.799
Mental toughness ->Performance efficacy (%)	14.15	3.78	< .001	.608

Discussion

In the present work, we conducted a psychological intervention with young tennis players focused on pre-service routines, expecting it to enhance players' performance. Particularly, we expected pre-service routines and players' ability to positively manage errors to be good indicators of mentally tough behaviors and, in turn, to predict a more positive performance.

Indeed, literature has reinforced this idea by showing that, alongside with physical conditioning, tactical and technical training, the development of mental skills oriented to encourage a more effective performance in competition has been used by tennis players (Gonzalez-Diaz, Gossner, & Rogers 2012). Thus, the positive impact of pre-performance routines has been suggested to satisfy a number of different roles, such as prescribing attentional focus and helping players to concentrate their thoughts on task-relevant cues, reducing the impact of distractions and overcoming negative thoughts, and perform better under pressure (Boutcher, 1992; Boutcher & Crews, 1987; Czech, et

al., 2004; Foster, Weigand, & Baines, 2006; Lautenbach et al, 2015; Mesagno, Marchant, & Morris, 2008).

Overall, the results of our study are consistent with previous literature showing that the implementation of pre-service routines was effective in enhancing athletes' performance (cf. Cotterill, 2010 for a review). As advocated by Cotterill (2008), the intervention approach was individualized for each athlete, as we used their practices to correct them and adapt different aspects of the routine (e.g. self-talk) to meet their specific needs. The intervention was particularly helpful in reducing the percentage of double-faults, and in improving players' performance efficacy (winning more points). The results also provide some preliminary data suggesting that mental toughness, predicted by players' ability to remain focused and positive, plays a very important role in predicting players' performance.

Regarding the first-serve percentage, the results showed an increase after the intervention, but this was not significant. This result is somewhat inconsistent with Moore (1986), and Daw and Burton (1994), in which tennis players slightly improved their first-serve percentage. However, their efficacy on first-serve was significantly higher when they performed the routine (comparing to when they did not), which suggests that players' first-serve efficacy is more related to their ability of remaining focused and concentrated before the shot.

Compared to a first-serve (after which the player still has another chance to put the ball into the service box), the second serve increases pressure, as the tennis player automatically loses the point in case of a fault (Lautenbach et al., 2015). Our results showed that the young players performed less double-faults after the intervention, which may suggest that pre-service routines were effective in helping the players to cope with the pressure of a second-serve. However, double-faults do not necessarily

occur due to anxiety resulting from a pressure situation. Thus, an alternative explanation might be that when performing the second-serve, the players re-evaluated the error made in the first-serve, and the routines helped them to keep their attention into the task-relevant information and, therefore, fail less. This explanation is consistent with one of the case studies presented by Daw and Burton (1994), in which the tennis player received a psychological skills training focused on mental routines (to help the player to improve relaxation and attention focus) aiming to reduce the double-fault percentage, and proved effective.

More interestingly, our research proposed that pre-service routine and error management are good behavioral indicators of mentally tough behavior and predict several performance indicators, including first-serve and double-fault percentages, as well as the overall performance efficacy. Our research provides a novel insight regarding the role of mental toughness, extending previous findings (cf. Cowden, 2017 for a review) by looking at mentally tough behavior and objective measures of performance. This is a different approach from what has been overall taken to study this phenomenon, and is particularly important to overcome social desirability and self-presentation biases (Hardy et al., 2014). Mental toughness is of great importance for tennis players, as they face several failures (errors) in a match, during which are required to sustain their determination and concentration (cf. Cowden et al., 2014; Galli & Gonzalez, 2015). Therefore, we argued that that being able to positively manage errors (that will necessarily arise during a tennis match) and stay positive when facing adversity is one way of reflecting mental toughness. This approach to measure mental toughness in tennis considers the complex dynamic of a tennis match, and the overall results supported this idea. One explanation may be that pre-service routines are key to close-skills (such as serve), impacting on its efficacy, and dealing positively with errors

also reinforces mental toughness, which comes into play when looking at the sequence of points and considering tennis as an open-skill sport. In this sense, the player's ability to remain consistently positive, focused and able to deal with aspects that may not depend directly on him/her, may play a key role. Future research is necessary to further support these conclusions, and to solve some of the limitations that this study encompasses.

One of the main limitations is the small sample size (n = 11), which limits the analyses that can be conducted. However, the unit of observation (athlete's service games) was much bigger (n = 45; n = 84). Nevertheless, a replication of the study with a bigger sample size and power will allow other statistical analyses to be conducted and strengthen the conclusions of the present research (cf. Schweizer & Furley, 2016). Conversely, it would also have been important to use some sort of social validation from participants so we could have a deeper insight on which purposes they used the routine for. Another limitation related to the design of the research is the absence of a control group. A control group would help establishing the impact of the intervention on performance (e.g. first-serve percentage, performance efficacy), but would not impact on the core content of the present research, as we assessed the impact of performing the routine (*vs.* not performing) within the same service game, and this analysis would not be possible to conduct with the control group as they would not perform the routine.

Previous literature has found that other individual differences play a role in the magnitude of the impact of pre-performed routines, such as personality, coping resources, commitment to the program, and self-confidence (e.g. Cotterill, 2010; Cotterill et al., 2010; Daw & Burton, 1994). These characteristics were not controlled for in our study, and their role on mental toughness would be particularly important to assess. Although we have looked at the complex dynamic of a tennis match, other

important variables should also be taken into account in future research, particularly the game, set and match result, as well as the temporal consistency of the routine which has been shown to improve with mental training (e.g., Moore, 1986).

Regardless of the importance of using behavioral measures to assess mental toughness, which is key to demonstrate the novelty of this study, the use of these measures is in itself a challenge, as they are more difficult to code, and some measures of performance might be confounded with talent and ability to perform (cf. Hardy et al., 2014). Moreover, and although most scholars seem to agree that it refers to a multidimensional construct that encompasses attributes such as self-efficacy, passion, hope, optimism, perseverance for long-term goals, and self-regulation (Gucciardi, Jackson, Hanton, & Reid, 2015), mental toughness has not been consistently operationalized in the literature. Indeed, there is still a heated debate about whether it is a trait or a disposition and how it may differ from other concepts such as hardiness and ability to cope with adversity (e.g., Anderson, 2011; Gucciardi & Gordon, 2011; Gucciardi, Gordon, & Dimmock, 2009; Gucciardi, Hanton, Gordon, Mallett, & Temby, 2015; Hardy et al., 2014; Ponnusamy et al., 2018; Weinberg, Butt, Mellano, & Harmison, 2017), which made this task particularly difficult. In order to keep it as objective as possible (or at least, as least subjective as possible), we translated mental toughness into observable behaviors (e.g. body language).

We also considered the whole point instead of focusing solely on serve performance, offering a wider picture of the impact of mental toughness, and taking into account the complexity of tennis, as the previous point affects the players' mental state to face the following ones. Future research addressing covert aspects (as players' inner thoughts) is particularly important. Moreover, previous research found differences in mental toughness between elite and college athletes (cf. Madrigal et al, 2013) –

therefore, comparing the results between junior athletes and professionals would also provide an insight on the phenomenon.

In order to ensure the comparability of conditions, the present study only looked at matches occurring during practice. Considering that athletes tend to use specific mental strategies more frequently in competition than practice (cf. Hall, Rodgers, & Barr, 1990; Jackson & Baker, 2001), a logical next step would be assessing if mental toughness plays the same role (and in the same magnitude) in predicting performance both practice and competition situations.

In sum, recent literature has shown a relationship between mental toughness and psychological interventions to develop mental skills such as pre-performance routines, concentration, imagery and self-talk (e.g. Gucciardi, Jackson, Hanton, & Reid, 2015; Mathers, 2016). Although a wide range of methods has been used, little research has focused on objective performance measures, and little is known about the impact of mental toughness on young tennis players' performance. Regardless the barriers in using this kind of approach, our research took a closer look to a number of performance indicators before and after players received mental training and learnt how to perform pre-service routines. The results showed a positive impact on players' performance, with pre-service routines helping them to remain focused and able to positively manage errors/ adversity, enhancing their mental toughness.

From an applied point of view, the results suggest that observed mentally tough behaviors can be a more important predictor of performance, and that interventions focused on increasing mentally tough behaviors might have a direct implication on performance. Therefore, our research highlights the need of developing mental training programs specifically focused on mental toughness behaviors. Conversely, it also reinforces the idea that individual skills, such as mental toughness, can be improved by

individualized mental training which, in turn, supports the need of sport psychologists focusing their efforts on developing mental training programs that improve performance-related skills on tennis players.

References

Anderson, M. B. (2011). Who's mental, who's tough, and who's both? Mutton constructs dressed up as lamb. In D. F. Gucciardi & S. Gordon (Eds.), *Mental toughness in sport: Developments in theory and research* (pp. 50–80). Oxford: Routledge

Bar-Eli, M., & Blumenstein, B. (2005). Performance enhancement in swimming: The effect of mental training with biofeedback. *Journal of Science and Medicine in Sport, 7*(4), 454-464. doi: 10.1016/S1440-2440(04)80264-0

Bell, J. J., Hardy, L., & Beattie, S. (2013). Enhancing mental toughness and performance under pressure in elite young cricketers: A 2-year longitudinal intervention. *Sport, Exercise, and Performance Psychology, 2*(4), 281-297. doi: 10.1037/a0033129

Boutcher, S. J., & Crews, D. J. (1987). The effect of preshot attentional routine on a well-learned skill. *International Journal of Sport Psychology, 18,* 30-39

Boutcher, S.H. (1992). Attention and athletic performance: An integrated approach. In T.S. Horn (Ed.), *Advances in sport psychology* (pp. 251 266). Champaign, IL: Human Kinetics

Burton, D., Pickering, M., Weinberg, R., Yukelson, D., & Weigand, D. (2010). The competitive goal effectiveness paradox revisited: Examining the goal practices of prospective Olympic athletes. *Journal of Applied Sport Psychology, 22*, 72-86. DOI: 10.1080/10413200903403232

Cohn, P. J., Rotella, R. J., and Lloyd, J. W. (1990). Effects of a cognitive-behavioral intervention on the preshot routine and performance in golf. *The Sport Psychologist, 4*, 33-47. DOI: 10.1123/tsp.4.1.33

Connaughton, D., Wadey, R., Hanton, S., & Jones, G. (2008). The development and maintenance of mental toughness: Perceptions of elite performers. *Journal of Sports Sciences, 26*, 83-95. DOI: 10.1080/02640410701310958

Cotterill, S. (2008). Developing effective pre-performance routines in golf. *Sport & Exercise Psychology Review, 4*(2), 10-16

Cotterill, S. (2010). Pre-performance routines in sport: current understanding and future directions. *International Review of Sport and Exercise Psychology, 3*(2), 132-153. DOI: 10.1080/1750984X.2010.488269

Cotterill, S., Sanders, R., & Collins, D. (2010). Developing effective pre-performance routines in golf: Why don't we ask the golfer? *Journal of Applied Sport Psychology, 22*, 51-64. DOI: 0.1080/10413200903403216

Cowden, R. C. (2017). Mental toughness and success in sport: a review and prospect. *Open Sports Sciences Journal, 10*(1), 1–14. DOI 10.2174/1875399X01710010001

Cowden, R. G., Fuller, D. K., & Anshel, M. H. (2014). Psychological predictors of mental toughness in elite tennis: An exploratory study in learned resourcefulness and competitive trait anxiety. *Perceptual and Motor Skills, 119*, 661-678. DOI: 10.2466/30.PMS.119c27z0

Czech, D. R., Ploszay, A. J., & Burke, K. L. (2004). An examination of the maintenance of preshot routines in basketball free throw shooting. *Journal of Sport Behavior, 27*, 323-329

D' Zurilla, T. J. (1988). Problem-solving therapies. In K. S. Dobson (Ed.), *Handbook of cognitive-behavioral therapies* (pp. 85-135). New York: Guilford

Daw, J., & Burton, D. (1994). Evaluation of a comprehensive psychological skills training program for collegiate tennis players. *The Sport Psychologist, 8*, 37-57. DOI: 10.1123/tsp.8.1.37

Defrancesco C., Burke K.L. (1997) Performance enhancement strategies used in a professional tennis tournament. *International Journal of Sport Psychology 28*, 185-195

Foster, D.J., Weigand, D.A., & Baines, D. (2006). The effect of removing superstitious behavior and introducing pre-performance routine on basketball free throw performance. *Journal of Applied Sport Psychology, 18,* 167-171. DOI: 10.1080/10413200500471343

Galli, N. & Gonzalez, S. P. (2015). Psychological resilience in sport: A review of the literature and implications for research and practice. *International Journal of Sport and Exercise Psychology, 13*(3), 243-257. doi: 10.1080/1612197X.2014.946947

Golby, J., & Sheard, M. (2004). Mental toughness and hardiness at different levels of rugby league. *Personality and Individual Differences, 37,* 933-942. doi: 10.1016/j.paid.2003.10.015

Gomes, A.R. (2010). *Promoção de experiências positivas em crianças e jovens: Programa de competências de vida* [Promoting positive experiences in children and youth: Life skills program]. Santa Maria da Feira: Associação High Play

Gonzalez-Diaz, J., Gossner, O., & Rogers, B.W. (2012). Performing best when it matters most: Evidence from professional tennis. *Journal of Economic Behavior and Organisations, 84*, 767-781. doi: 10.1016/j/jebo.2012.09.021

Gooding, A. & Gardner, F. L. (2009). An investigation of the relationship between mindfulness, preshot routine, and basketball free throw percentage. *Journal of Clinical Sports Psychology*, 4, 303-319. doi: 10.1123/jcsp.3.4.303

Gould, D., Dieffenbach, K., & Moffett, A. (2002). Psychological characteristics and their development in Olympic champions. *Journal of Applied Sport Psychology*, 14, 172–204. doi: 10.1080/10413200290103482

Gucciardi, D. F., & Gordon, S. (2009). Development and preliminary validation of the Cricket Mental Toughness Inventory (CMTI). *Journal of Sports Sciences, 27*(12), 1293-1310. doi: 10.1080/02640410903242306

Gucciardi, D. F., & Gordon, S. (2011). *Mental toughness in sport: Developments in research and theory*. Oxford: Routledge

Gucciardi, D. F., Gordon, S., & Dimmock, J. A. (2009). Advancing mental toughness research and theory using personal construct psychology. *International Review of Sport and Exercise Psychology*, 2, 54–72. doi: 10.1080/17509840802705938

Gucciardi, D. F., Hanton, S., Gordon, S., Mallett, C. J., & Temby, P. (2015). The concept of mental toughness: Tests of dimensionality, nomological network, and traitness. *Journal of Personality 83*, 26–44. doi 10.1111/jopy.12079

Gucciardi, D. F., Jackson, B., Hanton, S., & Reid, M. (2015). Motivational correlates of mentally tough behaviours in tennis. *Journal of Science and Medicine in Sport, 18*, 67-71. doi: 10.1016/j.jsams.2013.11.009

Hall, C. R., Rodgers, W. M., & Barr, K. A. (1990). The use of imagery by athletes in selected sports. *The Sport Psychologist, 4*, 1-10. doi: 10.1123/tsp.4.1.1

Hardy, L., Bell, J., & Beattie, S. (2014). A neuropsychological model of mentally tough behavior. Journal of Personality, 82, 69-81. doi: 10.1111/jopy.12034

Holland, M. J. G., Woodcock, C., Cumming, J., & Duda, J. L. (2010). Mental qualities and employed mental techniques of young elite team sport athletes. *Journal of Clinical Sport Psychology*, 4, 19-38. doi: 10.1123/jcsp.4.1.19

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*, 1–55. doi:10.1080/10705519909540118

Jackson, R. C., & Baker, J. S. (2001). Routines, rituals, and rugby: case study of a world class goal kicker. *The Sport Psychologist, 15*, 48-65. doi: 10.1123/tsp.15.1.48

Jones, G., Hanton, S., & Connaughton, D. (2002). What is this thing called mental toughness? An investigation of elite sport performers. *Journal of Applied Sport Psychology, 14*, 205-218. doi: 10.1080/10413200290103509

Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd ed.). New York, NY: Guilford Press

Lauer, L., Gould, D., Lubbers, P., & Kovacs, M. (2010). *USTA mental skills and drills handbook*. United States: Coaches Choice

Lautenbach, F., Laborde, S., Mesagno, C., Lobinger, B. H., Achtzehn, S., & Arimond, F. (2015). Nonautomated pre-performance routine in tennis: an intervention study. *Journal of Applied Sport Psychology, 27*, 123-131. doi: 10.1080/10413200.2014.957364

Lobmeyer, D. L., & Wasserman, E. A. (1986). Preliminaries to free throw shooting: Superticious behavior? *Journal of Sport Behavior, 9,* 70-78

Loehr, J. E. (1986). *Mental toughness training for sports: Achieving athletic excellence*. Lexington, MA: Stephen Greene Press

Madrigal, L., Hamill, S., & Gill, D. L. (2013). Mind over matter: The development of the mental toughness scale (MTS). *The Sport Psychologist, 27*, 62-77. doi: 10.1123/tsp.27.1.62

Mahoney, J. W., Gucciardi, D. F., Ntoumanis, N., & Mallett, C. J. (2014). Mental toughness in sport: Motivational antecedents and associations with performance and psychological health. *Journal of Sport and Exercise Psychology, 36*(3), 281–292. doi 10.1123/jsep.2013-0260

Mamassis, G. & Doganis, G. (2004). The effects of a mental training program on juniors pre-competitive anxiety, self-confidence, and tennis performance. *Journal of Applied Sport Psychology, 16,* 118-137. doi: 10.1080/10413200490437903

Mathers, J. F. (2016). Professional tennis on the ATP Tour: A case study of mental skills support. *The Sport Psychologist*. doi: 10.1123/tsp.2016-0012

Mesagno, C., Marchant, D., & Morris, T. (2008). A pre-performance routine to alleviate choking in "choking-susceptible" athletes. *The Sport Psychologist, 22*, 439-457. doi: 10.1123/tsp.22.4.439

Moore, W. E. (1986). *Covert-overt service routines: the effects of a service routine training program on elite tennis players* (unpublished doctoral dissertation). The University of Virginia, United States of America

Moran, A.P. (1996). *The psychology of concentration in sports performers: A cognitive analysis*. Hove: Psychology Press

Ponnusamy, V., Lines, R. L. J., Zhang, C., & Gucciardi, D. F. (2018). Latent profiles of elite Malaysian athletes' use of psychological skills and techniques and relations with mental toughness, *PeerJ, 6*. doi: 10.7717/peerj.4778

Schweizer, G. & Furley, P. (2016). Reproducible research in exercise psychology: the role of sample sizes. Psychology of Sport and Exercise, 23, 114-122. doi: 10.1016/j.psychsport.2015.11.005

Valentzas, K., & Heinen, T. (2011). Routine integration strategies and their effects on volleyball serve performance and players' movement mental representation. *Journal of Applied Sport Psychology, 23*, 209-222. doi: 10.1080/10413200.2010.546826

Valentzas, K., Heinen, T., Tenenbaum, G., & Schack, T. (2010). Functional mental representation of volleyball routines in German youth female national players. *Journal of Applied Sport Psychology, 22*, 474-485. doi: 10.1080/10413200.2010.504650

Weinberg, R. Freysinger, V., Mellano, K., & Brookhouse, E. (2016). Building mental toughness: Perceptions of Sport Psychologists. *The Sport Psychologist, 30*, 231-241. doi: 10.1123/tsp.2015-0090

Weinberg, R. S., & Gould, D. (2015). *Foundations of sport and exercise psychology* (6th edition). Campaing, IL: Human Kinetics

Weinberg, R., Butt, J., Mellano, K., & Harmison, R., (2017). The stability of mental toughness across situations: Taking a social-cognitive approach. *International Journal of Sport Psychology, 48*, 280–302. doi 10.7352/IJSP.2017.48.280

Wolframm, I. A., & Micklewright, D. (2011). The effect of mental training program on state anxiety and competitive dressage performance. *Journal of Veterinary Behavior Clinical Applications and Research, 6*(5). doi: 10.1016/j.jmb.2011.03.003

Zetou, E., Vernadakis, N., Bebetsos, E., & Makraki, E. (2012). The effect of self-talk in learning the volleyball service skill and self-efficacy improvement. *Journal of Human Sport & Exercise, 7*(4), 794-805. doi: 10.4100/jhse.2012.74.07