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Abstract

Choking in sport is precipitated by a broad range of documented antecedents. One potential antecedent that may hinder performance under pressure is physical exertion. In the current experiment, a within-subjects design was implemented with 50 student-athletes who completed 40 basketball free-throws in four manipulated conditions: higher pressure-running, higher pressure-no running, lower pressure-running, and lower pressure-no running. A repeated measures analysis of variance revealed that participants scored significantly lower in the higher-pressure conditions than the lower-pressure conditions. Furthermore, participants scored significantly higher in the no-running conditions compared to the running conditions. The current results are in keeping with the conventional wisdom that physical effort can undermine performance in pressure circumstances. The applied implications of these results are discussed and tentative conclusions drawn for sport psychologists, coaches, and athletes.

Keywords: Choking, anxiety, physical exertion, basketball, free-throw shooting

Introduction

Fans witnessed a close and high standard contest in the deciding game seven of the 2016 National Basketball Association (NBA) championship series between the Cleveland Cavaliers and the Golden State Warriors. Suddenly and inexplicably, the shooting skills of the Warriors, one of the best offensive teams of NBA history, seemed to evaporate as they missed eight consecutive shots in the final five minutes of the game, eventually losing the championship series. Observers were left wondering what was the cause of this sudden deterioration in shooting performance. Was it related to high pressure, crowd effects, fatigue or possibly a combination of these factors? The phenomenon of choking was defined originally as “performance decrements under pressure situations” (Baumeister, 1984, p. 610). Although no single operational definition of choking is universally accepted, recently choking has been defined as “heightened levels of perceived pressure and where incentives for optimal performance are at a maximum lead to acute or chronic forms of suboptimal performance or performing more poorly than expected given one's skill level and self-set performance expectations” (Gucciardi, Longbottom, Jackson, & Dimmock, 2010, p. 79). Mesagno and Hill (2013) also developed a more stringent definition; “an acute and considerable decrease in skill execution and performance when self-expected standards are normally achievable, which is the result of increased anxiety under perceived pressure” (p. 273).

Sport psychology and social psychology researchers have attempted to explain choking behavior by developing and testing choking theories. In recent decades, two predominant theories have emerged; the distraction theory (Carver & Scheier, 1981) and the self-focus theory (Baumeister, 1984). According to proponents of distraction theories, task-irrelevant thoughts, such as perceived pressure, occupy working memory and result in the athletes processing the required information for skill execution alongside competing cognitions. Concomitant with perceived anxiety is a type of dual-task condition for athletes, whereby anxiety competes with the information required for skill execution. Consequently, attentional resources are co-opted away from the execution of the primary task. This results in inefficient processing of task-relevant information, and possibly choking (e.g., Beilock & DeCaro, 2007; Markman, Maddox, & Worthy, 2006). Researchers have also tested and reported positively on the relevance of Processing Efficiency Theory (PET; Eysenck & Calvo, 1992), a derivative version of distraction theory, whereby athletes sometimes overcome inefficient processing under pressure by increasing effort (Murray & Janelle, 2003; Wilson, Smith, & Holmes, 2007). Employing effort, however, may not be sufficient or advisable in pressure circumstances, because attentional capacities may be overwhelmed by high levels of anxiety (Hill, Hanton, Matthews, & Fleming, 2010; Williams, Vickers, & Rodrigues, 2001).

Advocates of self-focus theories have explained that perceived pressure can increase the tendency to direct attention inwardly, especially for highly self-conscious athletes. That is, consciously processing and monitoring automated skills may lead to choking (Baumeister, 1984; Beilock & Carr, 2001; Hill, Hanton, Matthews, & Fleming, 2011; Jackson, Ashford, & Norsworthy, 2006; Lewis & Linder, 1997; Masters, 1992). Self-focus theories are contingent on stages of learning (Fitts & Posner, 1967). For example, a novice during performance attends to the explicit rule-based aspects of the skill rather than executing the task automatically. According to self-focus theorists, the process of well-learned and automated tasks operates outside working memory, and performance decrements can result from conscious processing and deliberate reinvestment in well-learned skill through working memory (Hill et al., 2010; Masters & Maxwell, 2008). The Explicit Monitoring Hypothesis (EMH; Beilock & Carr, 2001), and the Consciousness Processing Hypothesis (CPH; Masters, 1992) are the most renowned and cited self-focus theories. The key distinction is that Beilock and Carr, in describing EMH, state that step-by-step monitoring of performance causes disruption in the execution of skills, whereas Masters, in describing CPH, states that conscious controlling of the performance is detrimental. The available evidence shows that disrupting conscious control supersedes explicit monitoring as a detrimental performance explanation (Hill et al., 2010; Jackson et al., 2006; Marchant, Maher, & Wang, 2014). The Attentional Threshold Hypothesis (ATH; Hardy, Mullen, & Martin, 2001) has been proposed as an alternative hypothesis to explain performance decrements owing to the combination of anxiety-related cognitions and explicit cognitive instructions that exceed the attentional capacity threshold. Anxiety occupies a part of the attentional resources normally required for performance. Hence, diminution of attentional resources has a detrimental effect on performance when both anxiety-related cognitions and explicit instructions occur simultaneously (Gucciardi & Dimmock, 2008; Mesagno, Marchant, & Morris, 2009). The relevant literature generally supports the view that distraction theories are most salient for tasks that mainly demand working memory (e.g., fine motor skills), whereas, self-focus theories are most salient for tasks that do not strongly rely on working memory (e.g., gross motor skills) (Beilock & Carr, 2001; Lewis & Linder, 1997).

Sport psychologists have taken a close interest in the causes of choking from multi-dimensional perspectives combining the psychological, social and cognitive dimensions (Baumeister & Showers, 1986; Beilock, Kulp, Holt, & Carr, 2004; Hill, Hanton, Fleming, & Matthews, 2009). Researchers have ascribed the phenomenon of choking to a number of potential antecedents, including the presence of an audience (Wallace, Baumeister, & Vohs, 2005), stereotype threat (Chalabaev, Sarrazin, Stone, & Cury, 2008), public status (Jordet, 2009), fear of negative evaluation (Mesagno, Harvey, & Janelle, 2012), skill level and task properties (Beilock & Carr, 2001), personal attributes such as self-consciousness (Baumeister, 1984), trait anxiety and self-confidence (Baumeister & Showers, 1986; Baumeister, Hamilton, & Tice, 1985; Otten, 2009), coping style (Wang, Marchant, & Morris, 2004), perfectionism (Gucciardi et al., 2010), narcissism (Geukes, Mesagno, Hanrahan, & Kellmann, 2012, 2013; Wallace & Baumeister, 2002), and dispositional reinvestment (Jackson et al., 2006; Masters, Polman, & Hammond, 1993). Although there is now widespread recognition of the antecedents of choking, some potential contributors to performance decline, such as the influence of physiological and situational variables, have not been thoroughly investigated. The pressure of performing well and associated mental effort affects the physiological state of the organism, and the use of coping resources (Laborde, Lautenbach, & Allen, 2015). Qualitative investigations of choking episodes indicate that fatigue, particularly during the final stages of games in team sports, could result in significant under-performance in pressure circumstances (Hill & Shaw, 2013). Murayama and Sekiya (2015) found that under-performance relates to perceived feelings of physical heaviness and weakness. Researchers have recently demonstrated that elite junior basketball players predominantly perform at approximately 85% of maximum heart rate (HR) during games and that metabolic intensity and residual fatigue can influence on aspects of performance such as FT shooting (Padulo et al., 2015). Padulo et al. manipulated the influence of physiological pressure on FT shooting accuracy of participants under three conditions: at rest, 50% and 80% of maximum HR. They reported no significant difference between FT percentage at rest and 50% of the maximum HR (FT percentage about 80%). They did, however, report a significantly lower FT percentage at 80% of maximum HR with accuracy declining to 60%. In a related study, the effect of various exercise intensities on FT accuracy was investigated (Mokou, Nikolaidis, Padulo, & Apostolidis, 2016). Twenty-two, male youth basketball players, performed 50 total FTs under five conditions: at rest and after three-minute shuttle run at four different speeds. Mokou et al. (2016) found a significant effect of exercise intensity on FT accuracy, HR and rate of physical exertion. Moreover, the peak FT performance was observed during average exercise intensity, whereas FT accuracy declined at both rest and high intensity. The contrasting findings of a single-subject design reported no significant effects of physical fatigue on basketball shooting accuracy (Rupčić, Knjaz, Baković, Devrnja, & Matković, 2015).

Physical exertion as a potential cause of choking has not specifically been examined under varying pressure conditions. The aim of the present study was, therefore, to compare the extent to which physical exertion may affect FT performance under manipulated pressure conditions. We formulated two hypotheses: (a) higher pressure manipulation will significantly reduce performance compared to a lower pressure manipulation, and (b) intense pre-performance physical exertion will significantly reduce performance compared to a low level of pre-performance physical exertion.

Method

Design

A 2 × 2 repeated measure design was used, with physical exertion (running - no running) and relative pressure (higher pressure - lower pressure) as the independent variables. Basketball FT shooting performance was the dependent variable (see Table 1).

Table 1

Summary of Design and Variables

		Pressure	
		Higher pressure	Lower pressure
Physical Exertion	Running	HPR	LPR
	No running	HPNR	LPNR

Note. HPR = higher pressure-running; HPNR = higher pressure-no running; LPR = lower pressure-running; LPNR = lower pressure-no running.

Participants

Seventy-six undergraduate student-athletes initially volunteered to participate in the study. After a preliminary 10 FT shots trial to assess shooting proficiency, ongoing participation was restricted to 50 participants (13 female, 37 male), aged 18-26 (M_{age} = 23.37 years, SD = 4.34). The remaining 26 participants all scored less than four from10 attempts in the preliminary trial, and they were excluded to reduce the likelihood of floor effects affecting the data. That is, all remaining 50 participants scored a minimum 4 out of 10 attempts and thus demonstrated at least a minimal level of task proficiency (M_{FT} = 5.74, SD = 1.26)

Measures

Free-throw (FT) shooting. The performance task was basketball FT shooting, which has been widely used as an experimental task in choking studies (Fazel, 2015; Otten, 2009; Wang, Marchant, Morris, & Gibbs, 2004; Wilson, Vine, & Wood, 2009). Standard basketball equipment and facilities were used, according to specifications of the International Basketball Federation (FIBA). The scoring system adopted here was one point for each successful shot in the two lower pressure conditions and 3 points for each successful shot in the higher pressure conditions. The additional weighting or multiplier in the higher pressure conditions was part of the pressure manipulation.

Mental Readiness Form-3 (MRF-3). The MRF-3 (Krane, 1994) was used to measure perceived state anxiety levels of the participants before each of the four experimental blocks of 10 FTs. The MRF-3 is less invasive and time-consuming compared to longer questionnaires and is suitable when repeated in vivo measurements are required (Beseler, Mesagno, Young, & Harvey, 2016; Wilson et al., 2009). The MRF-3 contains three scales (two-ended continuums, ranged from 1-11). These separate scales measure cognitive anxiety (anchored between calm and worried), somatic anxiety (anchored between relaxed and tense), and self-confidence (anchored between confident and scared). In the present study, participants completed the MRF-3 before commencing each of four trial blocks of 10 FTs, to capture their feelings before initiating the trials.

Procedure

The 76 volunteers responded to the flyers that detailed the general purpose of the experiment. Standard informed consent and information procedures to the participants were followed. The first author explained the aims of the study and the experiment procedure to the participants. To determine shooting proficiency, all participants completed a preliminary FT screening trial, whereby they completed two practice shots then took 10 FTs under the supervision of a research assistant-scorer. The scoring was simply one point for each successful attempt. Participants' scores were then rank-ordered, and the 50 participants who scored four or above were asked to continue in the second phase of the experiment. The remaining 26 participants took the role of audience members in the higher pressure conditions. To control for order effects, a counterbalanced method was used (see Table 2).

Table 2

Counterbalancing Method

	Groups							
Order	1	2	3	4	5	6	7	8
1	HPR	HPR	HPNR	HPNR	LPR	LPR	LPNR	LPNR
2	LPR	LPNR	LPR	LPNR	HPR	HPNR	HPNR	HPR
3	HPNR	HPNR	HPR	HPR	LPNR	LPNR	LPR	LPR
4	LPNR	LPR	LPNR	LPR	HPNR	HPR	HPR	HPNR

Note. HPR = higher pressure-running; HPNR = higher pressure-no running; LPR = lower pressure-running; LPNR = lower pressure-no running.

Participants were randomly assigned to eight groups consisting of six participants in six groups and seven participants in two groups. Participants rotated through four conditions: higher pressure-running (HPR), lower pressure-running (LPR), higher pressure-no running (HPNR), and lower pressure-no running (LPNR). The groups were used to reduce the time needed to conduct the experiment and to introduce counterbalancing to reduce the likelihood of order effects. All participants performed 10 FTs in each condition. The running conditions were designed to investigate the effect of physical exertion on FT shooting performance. The pressure conditions were designed to investigate the effect of pressure on FT shooting performance.

Running conditions. In the two running conditions (i.e., HPR and LPR), participants completed timed shuttle runs, sprinting from the baseline to midcourt and returning to the baseline repeatedly, thus covering 56 meters in total before completing mini-blocks of two FTs. To encourage the participants to exert their best efforts in the shuttle-run, participants were also informed that the two fastest male and the fastest female (2:1 ratio based on the total participants) would receive a prize. After each timed shuttle run, the participants immediately walked 10 meters and completed two FTs. This running and shooting protocol was repeated five times until all 10 shots were completed. In the two no-running conditions (i.e., HPNR and LPNR), participants were instructed to walk slowly to the mid-court line after each pair of shots. The experiment was designed to increase physical exertion immediately before the FT task but not induce residual fatigue that could potentially influence later phases of the study. To the same end we ensured there was sufficent time between phases of the study for particiapnts to fully recover from the short-intense running manipulation.

Pressure conditions. In the two higher pressure conditions (i.e., HPR and HPNR), pressure was manipulated by (a) including the presence of audience (Belletier et al., 2015; Mesagno & Marchant, 2013) of students actively watching the performance from positions located around the key, (b) performance-contingent reward (Beseler et al., 2016; Mesagno et al., 2009) that translated into the top six scorers receiving rewards, ranging in value, from $15 to $75. The fastest three runners male and female (2:1 ratio) also received a similar choice of rewards, (c) video-recording (Mesagno, Marchant, & Morris, 2008; Otten, 2009) where students were told their shot would be recorded for evaluation purposes and as a possible means to double-check the outcome, and (d) increasing the points for each FT to amplify the relative magnitude of each shot in higher pressure conditions. In the higher pressure conditions, an audience of six student-athletes was placed around the FT rebounding positions (the key) to observe the performance, similar to what occurs in basketball games. The audience was instructed to remain silent, but to convey the attitude of an interested observer and to neither encourage nor discourage the participants. Participants had been briefed to do their best and that at the conclusion of the experiment the two best males and best female FT shooters would receive a prize. For data analyses purposes, however, irrespective of the condition, one point was entered for a successful shot. In the two lower pressure conditions (i.e., LPR and LPNR), participants performed the FT shot protocol without applying the manipulated pressure.

Data analysis

All analyses were conducted using the Statistical Package for the Social Sciences (SPSS). A 2 × 2 repeated measures analyse of variance (ANOVA) was conducted to examine potential differences in FT performance among four manipulated conditions and also potential differences in mental readiness scores among the designed conditions.

Results

Free-throw (FT) Shooting

Means and standard deviations of FT shooting performance across the four conditions are shown in Table 3. As expected, participants scored the highest when the pressure was lower with no physical exertion and scored lowest when both pressure and running were applied.

Table 3

Means and Standard Deviations of Free-throw Scores

Conditions	M	SD	n
HPR	4.14	2.17	50
HPNR	4.52	1.95	50
LPR	4.62	2.20	50
LPNR	5.34	1.98	50

Note. HPR = higher pressure-running; HPNR = higher pressure-no running; LPR = lower pressure-running; LPNR = lower pressure-no running.

Analysis of variance revealed a significant main effect for pressure F (1, 49) = 5.25, p = .02, $\eta_p{}^2$ =.09 corresponding to a medium effect. Participants scored significantly lower in the higher-pressure conditions compared to the lower-pressure conditions. There was also a significant main effect for running F (1, 49) = 10.13, p = .003, $\eta_p{}^2$ = .17 corresponding to a large effect. That is, participants scored significantly higher when not running before shooting compared to running before shooting. There were no significant interaction effects. Based on these results, the alternative hypothesis that FT performance would decline significantly in the higher-pressure conditions compared to the lower pressure conditions was accepted. Similarly, the alternative hypothesis that FT shooting would decline significantly in the higher physical exertion conditions compared to the low physical exertion conditions was also accepted. The main story in the present research was that manipulated pressure and physical exertion both cause choking, but are independent of each other. Furthermore, additional follow up regression analysis to detect whether gender predicted poor performance under higher pressure and running conditions was not significant.

Mental Readiness Form-3 (MRF-3)

To analyse the potential influence of anxiety on performance, we computed a repeated measure analysis of variance using MRF-3 scale scores. For the cognitive anxiety scale, No significant differences were found for the MRF-3 sub-scales in either the manipulated pressure conditions or running conditions.

Discussion

The aim of the present research was to investigate the effects of perceived pressure and physical exertion on basketball FT shooting performance. The results provide an insight into the relatively untested effects of physical exertion on performance under differential pressure and confirmed the a priori hypotheses that both the pressure manipulation and the pre-shooting running manipulation would produce significant downward effects on FT shooting accuracy.

The ability to successfully execute FTs is generally accepted as critical and potentially decisive in close basketball games, particularly in the final phase of games where players experience a combination of pressure, fatigue, and various emotions linked to the imminent game outcome (Gómez, Lorenzo, Jiménez, Navarro, & Sampaio, 2015). For example, analysts have shown that winning teams obtain approximately two-thirds of their score in the final three minutes of play from successful FTs (Lorenzo Calvo, Gómez Ruano, Ortega Toro, Ibañez Godoy, & Sampaio, 2010). The pressure to successfully convert FTs in the final seconds of close games (±3 points) in the most high-profile leagues, combined with residual game fatigue, represent an ideal platform from which to contextualize the results of the current research. That is, the current finding, that FT shooting performance declined significantly under conditions of higher pressure and higher physical exertion, reflects the types of performance decline that researchers have reported occurring in the final seconds of super elite leagues (Cao, Price, & Stone, 2011; Gómez et al., 2015; Ibáñez, Santos, & García, 2015; Toma, 2015). Toma (2015), for example, has recently reported FT shooting trends using reliable archival data extracted from the highly elite samples of players participating in the NBA, the Women's National Basketball Association (WNBA), and also the men's and women's National Collegiate Athletic Association (NCAA) between 2002-2013. By analysing over two million FT attempts, Toma reported that these super-elite players experience a substantial decline in FT shooting performance in the crucial final 30 seconds of close games (5.81%, 3.11%, 2.25% and 2.09% point declines in the WNBA, NBA, women's NCAA and men's NCAA, respectively). In the present study, the FT under-performance range across the four manipulated conditions was 1% - 12%. From a comparative perspective, a 5 - 10% FT performance decrease has been reported in the final seconds of close games in the NBA. Cao et al. (2011) analysed all FTs in the NBA between 2002 - 2010. The FT percentage declined 4% when the margin was ±2 points in the final minute. A further breakdown of the FT shooting trends in the final 15 seconds of games corresponded to a 6.3% decline when a team was down by 2 points and an 8.8% decline when a team was down by 1 point. In summary, the results of the current study reflect what happens in the field (i.e., high-level basketball competition). We emphasize this point because demonstrating results that are consistent with actual competition, is an important indicator of external validity. In this instance, we believe the experiment results to be both relevant and relatively important within the game performance context.

The results of the current study are consistent with previous choking studies from the pressure manipulation perspective (Beseler et al, 2016; Kinrade, Jackson, & Ashford, 2015; Mesagno & Marchant, 2013; Mesagno et al., 2008, 2009; Otten, 2009; Schücker, Hagemann, & Strauss, 2013). That is, a relative increase in manipulated pressure typically leads to a significant deterioration in performance. The relevant literature supports the view that distraction theories are most salient for tasks that strongly rely on working memory, whereas self-focus theories are most salient for tasks that are less reliant on working memory (Beilock & Carr, 2001; Lewis & Linder, 1997). Moreover, the predominant theories have been reported to predict choking depending on the skill level of athletes. Distraction theories can explain choking under pressure for novice players while self-focus theories can explain choking for more skilled players (Beilock & Gray, 2007). We believe a combination of both distraction and self-focus theories supports the findings of the current study, because we used student-athletes with a wide range of abilities, from domestic competition through to sub-elite competition, as the participants. Based on distraction theories, execution of the task can lead to performance deterioration, because attention shifts to irrelevant task cues or thoughts such as concerns about the consequences or the situation (Beilock & Carr, 2001; Lewis & Linder, 1997). Performance decrements often occur when irrelevant thoughts consume working memory that is required to execute the task. High-pressure situations can overwhelm attentional resources and negatively influence accomplishment of the task (Beilock & DeCaro, 2007; Gimmig, Huguet, Caverni, & Cury, 2006; Markman et al., 2006). The less skilled participants who performed poorly in the present study, would have needed to allocate additional working memory to execute the task under the manipulated pressure conditions where other distractions likely occupied their working memory. Hence, the distraction theory seems the most appropriate explanation for novice and less skilled participants. Based on self-focus theories, explicitly attending to task execution can result in performance decrements (Baumeister, 1984; Beilock & Carr, 2001; Hill et al., 2011; Masters, 1992). The more skilled participants who performed poorly under pressure may have attended consciously to the FT task rather than trusting automaticity. Despite the expected findings that FT performance deteriorated under higher pressure and running one anomaly remained that subjective anxiety levels as measured by the MRF-3 were not significantly different across conditions. The MRF-3 has not been widely used in sport anxiety research and generally the CSAI-2 has been favoured. With the benefit of hinsight we do have comments and concerns about the MRF-3 that researchers conducting similar studies may consider. We observed that completion times for the MRF-3 were exceptionally short and the participants did not seem to read or reflect in the style normally produced by longer questionnaires. Psychometricians have also raised concerns about the validity of questionnaires that use a single item to measure a scale and generally recommend using multiple item to measure a scale (e.g., Furr, 2011; Hatzigeorgiadis & Chroni, 2007; Hinkin, Tracey, & Enz, 1997).

The results of the present study are consistent with research demonstrating thatfatigue (i.e., sustained physical exertion can precipitate under-performance in pressure circumstances (Hill & Shaw, 2013; Laborde et al., 2015; Mokou et al., 2016; Murayama & Sekiya, 2015; Padulo et al., 2015). For example, researchers in two recent studies demonstrated that metabolic intensity due to fatigue decreased FT accuracy (Padulo et al., 2015), and also exercise intensity had a significant effect on FT accuracy, HR and rate of perceived exertion (Mokou et al., 2016). Results of the present study support the findings of Mokou et al. (2016) and Padulo et al. (2015) and demonstrate that physical exertion may lead to performance decrements especially under pressure circumstances.

In relation to the experimental manipulations in the present study, the pressure variable was modest in the context of what would be likely to be experienced in actual competition. Similarly, the physical exertion required in the current experiment was relatively minimal in comparison with the repeated intense physical exertion routinely experienced in basketball competition. Nevertheless, we recommend caution when interpreting the current findings. For both ethical and ecological reasons, participants were exposed to an increase in manipulated pressure. This limitation may ironically heighten the expectation that the effects of pressure and physical exertion might be stronger in actual competitions where more intense pressure is likely to be experienced. Likewise, the participants were exposed to an increase in physical exertion. However, the brief shuttle-run task would likely produce only a modest and short-term physiological effect compared to the intense extended efforts often required of players in actual game situations. To place the performance changes in a competitive context and encourage participants to apply more effort, we offered performance-contingent rewards. Although we used a pre-test to measure the FT shooting skill level of participants, we did not specifically measure the relative fitness level of participants. Anecdotally, we did, however, observe that those participants with observably better levels of fitness appeared to be more capable of executing the FT task successfully in the two running conditions. Also, researchers pursuing this line of research might consider measuring the actual physical exertion precisely, through known means such as precise monitoring of HR, cortisol levels, and blood lactate. Researchers might consider examining whether relative fitness and relative exertion have a moderating influence on performance under pressure. For example, monitoring HR using wristband telemetry, to ensure that participants reached a specified criterion level of fatigue before executing the performance task, might be used where non-invasive data collection is required in field settings.

Furthermore, although we used a pre-test to examine relative FT shooting ability to screen out relatively unskilled participants, and avoid floor effects, the range of abilities for the remaining participants was relatively broad (i.e., pre-test scores ranging from 4 - 9 in the 10 shot trial). Hence, recruiting participants from relatively narrow skill ranges may help to avoid the variability in the participant sample skill range. Also, one of the difficulties for choking studies is to address the issue of the reproducibility of choking, since creating stressful circumstances similar to real world situations is problematic, both practically and ethically. All participants in the current study had played competitive basketball. However, the participation range included domestic level basketball through to sub-elite level basketball. Nevertheless, deliberately recruiting an entirely sub-elite or elite sample presents other issues, such as the likely need to increase the intensity of the pre-shooting physical activity to produce commensurate physical exertion. More particularly, a balance needs to be struck between the level of manipulated pressure required to produce a discernible difference between lower and higher pressure manipulations, without contravening the strict cost-benefit boundaries that university ethics committees require.

Conclusions

The results of the present study extend previous research by demonstrating that physical exertion immediately before performance increases the likelihood of choking occurring. This has relevance for researchers, basketball players, basketball coaches and applied sports psychologists. Researchers might investigate whether these findings carry across to other sports that involve self-paced performance tasks (e.g., dart throwing, archery, penalty/set shot goal kicking and the tennis serve) intermittently and immediately after physical exertion.

Basketball players who struggle with shooting under pressure would likely be interested to know that physical exertion can exacerbate the negative effects of performing under pressure. Basketball coaches might reflect on the results of the present study to modify training to prepare players better for shooting in pressure circumstances (e.g., rehearse FT shooting immediately after intense physical exercise under pressure conditions). Furthermore, regarding external validity, the current results are immediately relevant to the sport of basketball, but also potentially relevant to other sports that require participants to perform self-paced tasks under pressure when preceded by physical exertion. Researchers might further investigate the effects of physical exertion on performance by manipulating the intensity of exertion and level of residual fatigue (e.g., early, middle and late game). Such research should be useful for coaches aiming to prepare athletes better for performing under pressure. Applied sport psychologists may be already aware of the numerous choking antecedents identified in the academic literature. They may also be aware of the choking specific interventions that have been used to ameliorate choking. The results of the present study should add to the relevant evidence-based knowledge that practitioners need to consider when designing client interventions.

The current results can be contextualised by revisiting accepted definitions of choking. For example, based on the Baumeister's (1984) definition that choking is "performance decrements under pressure situations," we believe that choking occurred in the present study. Alternatively, by applying the more recent definition of Mesagno and Hill (2013) that "an acute and considerable decrease in skill execution and performance when self-expected standards are normally achievable, which is the result of increased anxiety under perceived pressure" arguably the decline in performance many not have been sufficient to justify applying the choking label. That is, the level of under-performance in the present study was not necessarily acute, but it was statistically significant. We consider our results consistent with the findings of Toma (2015) who clearly showed that under-performance in pressure circumstances at the most elite levels is not necessarily acute, but is a systematic and robust finding. Thus regarding the applicability of the Mesagno and Hill definition, a considerable but not necessarily acute decrement occurred in both the present study and the Toma's study. Toma argued that the highest level of basketball players can choke in the final seconds of close games. Hence, the label choking is not only dependent on which definition of choking is cited but the circumstances or context in which the underperformance occurs. We invite other researchers also to examine how physical exertion can affect performance with other tasks, sports, and circumstances.

References

Baumeister, R. F. (1984). Choking under pressure: self-consciousness and paradoxical effects of incentives on skillful performance. *Journal of Personality and Social Psychology, 46*(3), 610-620.

Baumeister, R. F., Hamilton, J. C., & Tice, D. M. (1985). Public versus private expectancy of success: Confidence booster or performance pressure?. *Journal of Personality and Social Psychology, 48*(6), 1447-1457.

Baumeister, R. F., & Showers, C. J. (1986). A review of paradoxical performance effects: Choking under pressure in sports and mental tests. *European Journal of Social Psychology, 16*(4), 361-383.

Beilock, S. L., & Carr, T. H. (2001). On the fragility of skilled performance: what governs choking under pressure?. *Journal of experimental psychology: General, 130*(4), 701-725.

Beilock, S. L., & DeCaro, M. S. (2007). From poor performance to success under stress: Working memory, strategy selection, and mathematical problem solving under pressure. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*(6), 983–998.

Beilock, S. L., & Gray, R. (2007). Why do athletes “choke” under pressure? In G. Tenenbaum & R. C. Ecklund (Eds.), *Handbook of Sport Psychology* (pp. 425–444). Hoboken, NJ: Wiley.

Beilock, S. L., Kulp, C. A., Holt, L. E., & Carr, T. H. (2004). More on the fragility of performance: choking under pressure in mathematical problem solving. *Journal of Experimental Psychology: General, 133*(4), 584-600.

Belletier, C., Davranche, K., Tellier, I. S., Dumas, F., Vidal, F., Hasbroucq, T., & Huguet, P. (2015). Choking under monitoring pressure: being watched by the experimenter reduces executive attention. *Psychonomic Bulletin and Review, 22*(5), 1410-1416.

Beseler, B., Mesagno, C., Young, W., & Harvey, J. (2016). Igniting the Pressure Acclimatization Training Debate: Contradictory Pilot-Study Evidence from Australian Football. *Journal of Sport Behavior, 39*(1), 22-38.

Cao, Z., Price, J., & Stone, D. F. (2011). Performance under pressure in the NBA. *Journal of Sports Economics*, *12*(3), 231-252.

Carver, C. S., & Scheier, M. F. (1981). Attention and self-regulation: A control-theory approach to human behavior. New York, NY: Springer Verlag. doi:10.1007/978-1-4612-5887-2

Chalabaev, A., Sarrazin, P., Stone, J., & Cury, F. (2008). Do achievement goals mediate stereotype threat? An investigation on females' soccer performance. *Journal of Sport and Exercise Psychology*, *30*(2), 143-158.

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition and Emotion, 6*(6), 409-434.

Fazel, F. (2015). *The effects of different types of imagery delivery on performance and self-efficacy* (Doctoral dissertation). Retrived from http://vuir.vu.edu.au/30151/1/Fatemeh%20Fazel.pdf.

Fitts, P. M. & Posner, M. I. (1967). *Human performance.* Belmont, CA: Brooks/Cole.

Furr, M. (2011). Core principles, best practices and an overview of scale construction. In M. Furr (Eds.), *Scale Construction and Psychometrics for Social and Personality Psychology*, (pp. 4-15). London: SAGE.

Geukes, K., Mesagno, C., Hanrahan, S. J., & Kellmann, M. (2012). Testing an interactionist perspective on the relationship between personality traits and performance under public pressure. *Psychology of Sport and Exercise,13*(3), 243-250.

Geukes, K., Mesagno, C., Hanrahan, S. J., & Kellmann, M. (2013). Performing under pressure in private: Activation of self-focus traits. *International Journal of Sport and Exercise Psychology*, *11*(1), 11-23.

Gimmig, D., Huguet, P., Caverni, J. P., & Cury, F. (2006). Choking under pressure and working memory capacity: When performance pressure reduces fluid intelligence. *Psychonomic Bulletin and Review, 13*(6), 1005-1010.

Gómez, M. Á., Lorenzo, A., Jiménez, S., Navarro, R. M., & Sampaio, J. (2015). Examining choking in basketball: Effects of game outcome and situational variables during last 5 minutes and overtimes. *Perceptual and Motor Skills, 120*(1), 111-124.

Gucciardi, D. F., & Dimmock, J. A. (2008). Choking under pressure in sensorimotor skills: Conscious processing or depleted attentional resources?. *Psychology of Sport and Exercise, 9*(1), 45-59.

Gucciardi, D. F., Longbottom, J. L., Jackson, B., & Dimmock, J. A. (2010). Experienced golfers' perspectives on choking under pressure. *Journal of Sport and Exercise Psychology, 32*(1), 61-83.

Hardy, L., Mullen, R., & Martin, N. (2001). Effect of task-relevant cues and state anxiety on motor performance. *Perceptual and Motor Skills, 92*(3), 943-946.

Hatzigeorgiadis, A., & Chroni, S. (2007). Pre-competition anxiety and in-competition coping in experienced male swimmers. *International Journal of Sports Science and Coaching, 2*(2), 181-189.

Hill, D. M., Hanton, S., Fleming, S., & Matthews, N. (2009). A re-examination of choking in sport. *European Journal of Sport Science, 9*(4), 203-212.

Hill, D.M., Hanton, S., Matthews, N., & Fleming, S. (2011). Alleviation of choking under pressure in elite golf: an action research study. *The Sport Psychologist, 25*(4), 465-488.

Hill, D. M., Hanton, S., Matthews, N., & Fleming, S. (2010). Choking in sport: A review. *International Review of Sport and Exercise Psychology, 3*(1), 24-39.

Hill, D. M., & Shaw, G. (2013). A qualitative examination of choking under pressure in team sport. *Psychology of Sport and Exercise*, *14*(1), 103-110.

Hinkin, T. R., Tracey, J. B., & Enz, C. A. (1997). Scale construction: Developing reliable and valid measurement instruments. *Journal of Hospitality and Tourism Research*, *21*(1), 100-120.

Ibáñez, S. J., Santos, J. A., & García, J. (2015). Multifactorial analysis of free throw shooting in eliminatory basketball games. *International Journal of Performance Analysis in Sport, 15*(3), 897-912.

Jackson, R. C., Ashford, K. J., & Norsworthy, G. (2006). Attentional focus, dispositional reinvestment, and skilled motor performance under pressure. *Journal of Sport and Exercise Psychology*, *28*(1), 49-68.

Jordet, G. (2009). Why do English players fail in soccer penalty shootouts? A study of team status, self-regulation, and choking under pressure. *Journal of Sports Sciences, 27*(2), 97-106.

Jordet, G., & Hartman, E. (2008). Avoidance motivation and choking under pressure in soccer penalty shootouts. *Journal of Sport and Exercise Psychology, 30*(4), 450-457.

Kinrade, N. P., Jackson, R. C., & Ashford, K. J. (2015). Reinvestment, task complexity, and decision making under pressure in basketball. *Psychology of Sport and Exercise, 20*, 11-19.

Krane, V. (1994). The mental readiness form as a measure of competitive state anxiety. *The Sport Psychologist, 8*(2), 189-202.

Laborde, S., Lautenbach, F., & Allen, M. S. (2015). The contribution of coping-related variables and heart rate variability to visual search performance under pressure. *Physiology and Behavior*, *139*, 532-540.

Lewis, B. P., & Linder, D. E. (1997). Thinking about choking? Attentional processes and paradoxical performance. *Personality and Social Psychology Bulletin, 23*(9), 937-944.

Lorenzo Calvo, A., Gómez Ruano, M. Á., Ortega Toro, E., Ibañez Godoy, S. J., & Sampaio, J. (2010). Game related statistics which discriminate between winning and losing under-16 male basketball games. *Journal of Sports Science and Medicine, 9*(4), 664-668.

Marchant, D., Maher, R., & Wang, J. (2014). Perspectives on choking in sport. In A. G. Papaioannou & D. Hackfort (Eds.), *Routledge Companion to Sport and Exercise Psychology: Global Perspectives and Fundamental Concepts* (pp. 446-459). Routledge.

Markman, A. B., Maddox, W. T., & Worthy, D. A. (2006). Choking and excelling under pressure. *Psychological Science, 17*(11), 944-948.

Masters, R. S. W. (1992). Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *British Journal of Psychology, 83*(3), 343-358.

Masters, R. S. W., & Maxwell, J. P. (2008). The theory of reinvestment. *International Review of Sport and Exercise Psychology, 1*(2), 160-183.

Masters, R. S. W., Polman, R. C., & Hammond, N. V. (1993). ‘Reinvestment’: A dimension of personality implicated in skill breakdown under pressure. *Personality and Individual Differences, 14*(5), 655-666.

Mesagno, C., Geukes, K., & Larkin, P. (2015). Choking under pressure: A review of current debates, literature, and interventions. *Contemporary Advances in Sport Psychology: A Review*, 148-174.

Mesagno, C., Harvey, J. T., & Janelle, C. M. (2012). Choking under pressure: The role of fear of negative evaluation. *Psychology of Sport and Exercise, 13*(1), 60-68.

Mesagno, C., & Hill, D. M. (2013). Definition of choking in sport: re-conceptualization and debate. *International Journal of Sport Psychology, 44*(4), 267-277.

Mesagno, C., & Marchant, D. (2013). Characteristics of polar opposites: An exploratory investigation of choking-resistant and choking-susceptible athletes. *Journal of Applied Sport Psychology, 25*(1), 72-91.

Mesagno, C., Marchant, D., & Morris, T. (2008). A pre-performance routine to alleviate choking in “choking-susceptible” athletes. *The Sport Psychologist, 22*(4), 439-457.

Mesagno, C., Marchant, D., & Morris, T. (2009). Alleviating choking: The sounds of distraction. *Journal of Applied Sport Psychology, 21*(2), 131-147.

Mesagno, C., & Mullane-Grant, T. (2010). A comparison of different pre-performance routines as possible choking interventions. *Journal of Applied Sport Psychology, 22*(3), 343-360.

Mokou, E., Nikolaidis, P. T., Padulo, J., & Apostolidis, N. (2016). The acute effect of exercise intensity on free throws in young basketball players. *Sport Sciences for Health, 12*(2), 227–232.

Murayama, T., & Sekiya, H. (2015). Factors related to choking under pressure in sports and the relationships among them. *International Journal of Sport and Health Science, 13*, 1-16.

Murray, N. P., & Janelle, C. M. (2003). Anxiety and performance: A visual search examination of the processing efficiency theory. *Journal of Sport and Exercise Psychology, 25*(2), 171-187.

Otten, M. P. (2009). Choking vs. clutch performance: A study of sport performance under pressure. *Journal of Sport and Exercise Psychology, 31*(5), 583-601

Padulo, J., Attene, G., Migliaccio, G. M., Cuzzolin, F., Vando, S., & Ardigò, L. P. (2015). Metabolic optimisation of the basketball free throw. *Journal of Sports Sciences, 33*(14), 1454-1458.

Rupčić, T., Knjaz, D., Baković, M., Devrnja, A., & Matković, B. R. (2015). Impact of fatigue on accuracy and changes in certain kinematic parameters during shooting in basketball. *Hrvatski športskomedicinski vjesnik, 30*(1), 15-20.

Schmidt, A. (2012). Movement pattern recognition in basketball free-throw shooting. *Human Movement Science, 31*(2), 360-382.

Schücker, L., Hagemann, N., & Strauss, B. (2013). Attentional processes and choking under pressure. *Perceptual and Motor Skills, 116*(2), 671-689.

Toma, M. (2015). Missed Shots at the Free-Throw Line: Analyzing the Determinants of Choking Under Pressure. *Journal of Sports Economics,* doi:10.1177/1527002515593779.

Vickers, J. N., & Williams, A. M. (2007). Performing under pressure: The effects of physiological arousal, cognitive anxiety, and gaze control in biathlon. *Journal of Motor Behavior, 39*(5), 381-394.

Wallace, H. M., & Baumeister, R. F. (2002). The performance of narcissists rises and falls with perceived opportunity for glory. *Journal of Personality and Social Psychology, 82*(5), 819–834.

Wallace, H. M., Baumeister, R. F., & Vohs, K. D. (2005). Audience support and choking under pressure: A home disadvantage?. *Journal of Sports Sciences, 23*(4), 429-438.

Wang, J., Marchant, D., & Morris, T. (2004). Coping style and susceptibility to choking. *Journal of Sport Behavior, 27*(1), 75-92.

Wang, J., Marchant, D., Morris, T., & Gibbs, P. (2004). Self-consciousness and trait anxiety as predictors of choking in sport. *Journal of Science and Medicine in Sport, 7*(2), 174-185.

Williams, A.M., Vickers, J., & Rodrigues, S. (2001). The effects of anxiety on visual search, movement kinematics, and performance in table tennis: a test of Eysenck and Calvo's processing efficiency theory. *Journal of Sport and Exercise Psychology, 24*(4), 438-455.

Wilson, M., Smith, N. C., & Holmes, P. S. (2007). The role of effort in influencing the effect of anxiety on performance: Testing the conflicting predictions of processing efficiency theory and the conscious processing hypothesis. *British Journal of Psychology*, *98*(3), 411-428.

Wilson, M. R., Vine, S. J., & Wood, G. (2009). The Influence of Anxiety on Visual Attentional Control in Basketball Free Throw Shooting. *Journal of Sport and Exercise Psychology, 31*(2), 152-168.