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Stress responses, competition, and free-throw performance: The predicting role of other-approach goals

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Abstract:	Experimental stress paradigms have been little used in the sport psychology literature because they are unrelated to the specific sport task. The Trier Social Stress Test (TSST) was used in the present study to investigate its influence on the free-throw performance of skilled basketball players. We also investigated the influence of adopting other-approach goals (i.e., doing well relative to others) on free-throw performance when basketball players were placed in a competition immediately after the TSST, comparatively with a control condition without competition. The results showed that free-throw performance decreased in the control condition, while free-throw performance remained stable when the TSST was followed by a competition. They also highlighted that other-approach goals were significant positive predictors of post-TSST performance in the competition condition but not in the control condition. The TSST may now be used with skilled players as an experimental stress paradigm to induce acute stress in the sport domain.

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Abstract

Experimental stress paradigms have been little used in the sport psychology literature because they are unrelated to the specific sport task. The Trier Social Stress Test (TSST) was used in the present study to investigate its influence on the free-throw performance of skilled basketball players. We also investigated the influence of adopting other-approach goals (i.e., doing well relative to others) on free-throw performance when basketball players were placed in a competition immediately after the TSST, comparatively with a control condition without competition. The results showed that free-throw performance decreased in the control condition, while free-throw performance remained stable when the TSST was followed by a competition. They also highlighted that other-approach goals were significant positive predictors of post-TSST performance in the competition condition but not in the control condition. The TSST may now be used with skilled players as an experimental stress paradigm to induce acute stress in the sport domain.

Keywords: cortisol, sports, anxiety, psychology

Stress responses, competition, and free-throw performance: The predicting role of other-approach goals

Introduction

Understanding competitive sport performance is a recurrent concern for sport scientists, coaches, and athletes (Nevill, Atkinson, & Hughes, 2008), based on several theoretical frameworks. In this perspective, stress and achievement goals are major topics of interest in the sport psychology literature. But they have generally been studied separately to understand competitive sport performance, principally with correlational designs. Moreover, the use of experimental stress paradigms in the sport domain has been underrepresented because they are unrelated to the sport task itself. For example, the most robust experimental stress paradigm (i.e., the Trier Social Stress Test (TSST); Kirschbaum, Pirke, & Hellhammer, 1993) has been used rarely in the sport performance domain. This being so, the purposes of this study were to investigate through an experimental design (a) the consequences of the TSST on the free-throw performance of skilled basketball players, (b) the consequences of competition on the free-throw performance of previously stressed basketball players and the predicting role of other-based goals to better explain performance.

Stress – sport performance relationships in experimental studies

Stress appears when a discrepancy arises between the perceived demands of the task and the coping resources available to face this task (Lazarus & Folkman, 1994). Increased stress may impair sport performance (Frenkel et al., 2019a, 2019b) and may also lead to choking, i.e., acute performance decrements due to high pressure situations (Baumeister, 1984). Stress induces psychological (e.g., state anxiety), physiological (e.g., the secretion of glucocorticoids such as cortisol), and behavioral responses (Allen, Kennedy, Dockray, Cryan, Dinan, & Clarke, 2017). These stress responses have been shown to often negatively influence motor performance (Nieuwenhuys & Oudejans, 2012). But the fact that

Free-throw performance following acute stress

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3 psychological stress responses (e.g., anxiety) are always detrimental to performance and need
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5 to be reduced whenever possible should be considered a myth (McCarthy, Wilson, Keegan &
6
7 Smith, 2012). Indeed, some athletes maintain high levels of performance and others even tend
8
9 to perform better than usual (“clutch performance”, Otten, 2009) while they experience
10
11 stressful situations. But the number of experimental studies conducted in the laboratory and
12
13 focusing on stress – sports performance relationships is limited (Frenkel et al., 2019b). This
14
15 kind of study uses experimental stress paradigms which are not directly related to sport tasks.
16
17 For example, Lautenbach (2017) used a physical stressor (i.e., immersing participants’ arm in
18
19 ice water, up to the elbow, for three minutes) to induce stress. Subsequent golf performance in
20
21 a putting task was not influenced by this experimental stressor. Surprisingly, the Trier Social
22
23 Stress Test (TSST, Kirschbaum et al., 1993) is strongly underrepresented in experimental
24
25 studies focusing on stress – motor performance relationships, although this extensively used
26
27 paradigm has been considered the gold standard for examining the role of acute psychosocial
28
29 stress on cognitive performance, for example with tasks involving working memory
30
31 performance (Allen et al., 2017). Psychosocial stress is induced through two tasks (a mock
32
33 job interview and a mental arithmetic test) performed in front of a camera and two or three
34
35 unknown experimenters who have a cold attitude. The TSST induces stress through the
36
37 combination of social-evaluative threat and uncontrollability (Dickerson & Kemeny, 2004).
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44 Studies conducted with the TSST in the sport domain often focused on the influence
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46 of the level of physical activity on stress reactivity following the TSST (e.g., Mizzi & Heisz,
47
48 2018; Rimmelé et al., 2007; for a review see Mücke, Ludyga, Colledge, & Gerber, 2018). But
49
50 performance in sport tasks following the TSST was not assessed in these studies. But the use
51
52 of these kinds of experimental stress paradigms in the sport performance domain may be
53
54 called into question because they are unrelated to the sport task itself (Kivlighan & Granger,
55
56 2006) and because performance in competitive sports needs to be delivered within a
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3 threatening and stress-inducing environment. Rohleder, Beulen, Chen, Wolf, and Kirschbaum
4
5 (2007) also showed that the cortisol response of competitive ballroom dancers was higher in
6
7 real-life competition than in the TSST. However, conducting laboratory investigations
8
9 focusing on the influence of psychosocial stress induction (through the TSST) on motor
10
11 performance may be relevant for several reasons: (1) it is undoubtedly impossible to
12
13 experimentally induce stress during real-life competitions to measure its influence on sport
14
15 performance, which would certainly be refused by both coaches and athletes; (2) Rimmel et
16
17 al. (2007) highlighted that even elite players (national or Olympic levels) showed significant
18
19 psychological (i.e., anxiety increases) and physiological (i.e., salivary cortisol levels and heart
20
21 rate increases) stress responses to the TSST, and (3) the influence of cortisol on cognition was
22
23 recently highlighted as a way to explain physical functioning and sport performance (e.g.,
24
25 Lautenbach, 2017; Robazza et al., 2012).

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29
30 Two studies used the second part of the TSST only (i.e., the mental arithmetic task) to
31
32 investigate the influence of this stress induction on sport performance. Lautenbach, Laborde,
33
34 Achtzehn, & Raab (2014) showed a negative correlation between salivary cortisol levels and
35
36 performance in a second tennis serves task. Lautenbach, Laborde, Mesagno, Lobinger,
37
38 Achtzehn, & Arimond (2015) highlighted that the use of a non-automated pre-performance
39
40 routine in tennis serves helped to keep participants' performance consistent in the high-
41
42 pressure condition induced by the second part of the TSST. Despite these interesting results,
43
44 state anxiety significantly increased following the mental arithmetic task in the two previous
45
46 studies, but this was not the case for the salivary cortisol levels. This can certainly be
47
48 explained by the fact that only the second part of the TSST was used, and not the protocol as a
49
50 whole, including the mock job interview and the mental arithmetic test in front of a panel of
51
52 experimenters (Kirschbaum et al., 1993). In the sport performance domain, the whole TSST
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54 has been used in one experimental study only, examining the consequences of this paradigm
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Free-throw performance following acute stress

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3 on free-throw performance of beginners in basketball (Mascret et al., 2016). The results
4
5 showed that no effect was found on free-throw performance and movement execution due to
6
7 the very low free-throw level of the participants, who were beginners. Because the TSST is
8
9 the experimental stress paradigm inducing the most elevated levels of cortisol (Allen et al.,
10
11 2017) and because only one study has used it in the sport domain, studying its influence on
12
13 sport performance needs to be pursued. Following the null effect of the TSST on free-throw
14
15 performance of basketball beginners, it seems relevant to examine if similar results may be
16
17 found with basketball players in clubs who have a more stable free-throw technique and a
18
19 better initial performance level, since Beilock & Carr (2001) showed that one of the
20
21 psychological responses to stress, namely anxiety, may disrupt the automatic execution of a
22
23 motor task, impairing performance. Studying the influence of the TSST on free-throw
24
25 performance of skilled basketball players was the first aim of the present study.
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30 **Competition, sport performance, and other-based goals**

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32
33 As previously highlighted by Dickerson and Kemeny (2004) for the TSST, the
34
35 combination of social-evaluative threat and uncontrollability induces the strongest stress
36
37 responses. The combination of social evaluation of performance (by coaches, teammates,
38
39 and/or audience) and the uncontrollability of the task (uncertainty of the result) is also
40
41 inherent parts of competitive sport (Salvador & Costa, 2009). Competition was defined as
42
43 normative comparison between individuals (Murayama & Elliot, 2012). Competition is
44
45 naturally an integral part of sport because it implies that one or several individuals try to
46
47 achieve a goal by confronting another individual or another group who want to reach the same
48
49 goal. As in the animal and human literatures (e.g., Salvador & Costa, 2009), competition and
50
51 its outcomes are considered in sport research as a significant form of social stress which
52
53 results in physiological, psychological, and behavioral consequences (Costa & Salvador,
54
55 2012). There is an effect of sport competition itself with an increase in cortisol (e.g., Filaire et
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Free-throw performance following acute stress

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2
3 al., 2009; Rohleder et al., 2007) and anxiety (e.g., Hanton et al., 2008). Recently, Hogue and
4
5 colleagues (2013, 2017) also showed that a coach who promoted competition produced a
6
7 psychologically (i.e., increases of competitive state anxiety) and physiologically (i.e.,
8
9 increases of salivary cortisol levels) stressful environment in a juggling task. Competition
10
11 between individuals induces stress responses and increases the likelihood that choking occurs
12
13 (Baumeister, 1984) because the evaluations of performance and the associated results are
14
15 emphasized (Breske, Fry, Fry, & Hogue, 2017). While competition between athletes is
16
17 frequently used by coaches in the sport context to motivate their athletes (Hogue, Fry, & Fry,
18
19 2017), previous studies rather showed that competition induces above all a stressful
20
21 environment. But what happens if athletes are placed in a competitive situation while they are
22
23 already stressed before the beginning of the competition?
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29 We may hypothesize that it depends on their psychological characteristics, especially
30
31 on their trait competitiveness, which is a dispositional preference to compete with others in
32
33 situations in which their performance is evaluated (Spence & Helmreich, 1983). Achievement
34
35 goal theory specifically focused on behaviors oriented towards demonstrating competence or
36
37 avoiding demonstrating incompetence when an individual's performance is evaluated (for an
38
39 historical overview, see Elliot, Murayama, & Pekrun, 2011). Consequently, an individual may
40
41 pursue different kinds of achievement goals, which represent strivings focused on competence
42
43 (i.e., how well or poorly an individual is doing at a task or activity) and concrete aims that
44
45 emerge from personality characteristics such as achievement motives (Elliot et al., 2011).
46
47 Two kinds of goals seemed particularly relevant for our own research because some athletes
48
49 may be more or less concerned with demonstrating normative competence than others and
50
51 because trait competitiveness is a positive predictor of these two goals (Murayama & Elliot,
52
53 2012). Individuals may pursue other-approach goals (focused on doing well relative to others)
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Free-throw performance following acute stress

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3 and/or other-avoidance goals (focused on not doing poorly relative to others).¹ Recent meta-
4
5 analyses of self-reported achievement goals and objective performance in the sport domain
6
7 (e.g., Lochbaum & Gottardy, 2015; Van Yperen, Blaga, & Postmes, 2014) have evidenced
8
9 that other-approach goals were positively associated with performance attainment, whereas no
10
11 significant correlations were found between other-avoidance goals and sport performance.
12
13 Some experimental studies have also evidenced that situationally induced other-approach
14
15 goals (i.e., promoting competition between participants) may cause better performance in
16
17 basketball dribbling tasks (e.g., Elliot, Cury, Fryer, & Huguet, 2006), golf-putting exercises
18
19 (Kavussanu, Morris, & Ring, 2009), and dart-throwing exercises (e.g., Ntoumanis,
20
21 Thøgersen-Ntoumani, & Smith, 2009). In all these studies, competition between participants
22
23 was experimentally induced while they were not particularly stressed. Consequently, several
24
25 questions may arise. Would the pattern of results be the same if athletes were already
26
27 stressed? Would the stress induced by competition itself be added to the stress previously
28
29 experienced by athletes? Would cumulative stress effects be deleterious or beneficial for sport
30
31 performance? These questions were theoretically relevant because the compatibility between
32
33 competition and dispositional other-approach goals may induce a kind of stress-buffering
34
35 effect, which may in turn positively influence performance. Indeed, dispositional orientations
36
37 (e.g., dispositional affects, Janicki Deverts, Cohen, & Doyle, 2017) have already been found
38
39 to influence stress-buffering effects in other domains than sport. Hence, we postulate that
40
41 being in competition immediately after an acute stress may positively influence the
42
43 performance of athletes who adopt other-approach goals. Testing this hypothesis was the
44
45 second aim of the present study.
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57 ¹ Performance-based goals were recently relabeled other-based goals (Elliot et al., 2011; Mascret, Elliot, & Cury,
58 2015) but their definition remain the same. The more recent denomination (i.e., other-approach and other-
59 avoidance goals) is used in the present study even for studies employing the denomination performance-
60 approach and performance-avoidance goals.

Free-throw performance following acute stress

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3 Free-throw shooting was selected in the present study because (a) the player may
4 easily compare his performance with other players in a competition conducted in an
5 experimental setting; (b) players may pursue other-approach goals (e.g., “make more free
6 throws than others”) and/or other-avoidance goals (e.g., “not make fewer free throws than
7 others”) through this specific skill; (c) it is one of the most important and stress-provoking
8 game situations in basketball; (d) the player controls his stereotyped movement and performs
9 a standardized performance task; and (e) the cortisol consequences linked to the physical
10 exertion during a sequence of free throws can be neglected (Mascret et al., 2016).

21 **The present study**

22
23 The first aim of the study was to investigate the influence of an experimental stress
24 paradigm unrelated to sport tasks (i.e., the TSST) on free-throw performance of skilled
25 basketball players. Because the TSST induces acute psychosocial stress responses and
26 because skilled basketball players have a stabilized shooting movement, we expected the free-
27 throw performance of skilled basketball players to decrease after the TSST compared with
28 their performance before the TSST (Hypothesis 1). The second aim of the study was to
29 investigate the influence of adopting other-approach goals on free-throw performance when
30 basketball players were placed in a competition immediately after the TSST, by comparing
31 their performance pre-TSST and post-TSST and comparing their performance with a control
32 condition (no competition). Because other-approach goals and attractiveness of competition
33 were theoretically and empirically related (Murayama & Elliot, 2012), we expected other-
34 approach goals to be positive predictors of free-throw performance post-TSST when
35 participants were placed in a competition immediately after the TSST (Hypothesis 2). But we
36 hypothesized that other-approach goals were not significant predictors of free-throw
37 performance post-TSST when no competition was organized immediately after the TSST
38 (Hypothesis 3).

Methods

Participants

Thirty-eight men (18.50 ± 0.92 years with a range of 18-21 years; Body Mass Index of 22.70 ± 2.62 kg/m²) voluntarily participated in the study. The selected participants were students at the Faculty of Sports Science in Marseilles (France). They were all amateur basketball players in clubs at departmental to regional levels. A power analysis using G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007) showed that an $n = 17$ per condition was needed to produce desirable power of greater than 0.8 (using medium effect size = 0.25).

One month before the beginning of the experiment, all the participants completed a questionnaire collecting general information and a scale measuring their other-based goals. Exclusion criteria were the following: history of endocrine disorder, chronic stress, cardiovascular diseases, psychological distress, reported medical illness, drugs abuse, medication intake, drinking more than two glasses of alcohol a day, and smoking more than five cigarettes a day. Elite players were excluded from the study, because they showed lower cortisol responses to stress compared with amateur sportsmen (Rimmele et al., 2007). Participants also had to follow specific instructions: not to take medication, not to use alcohol, and not to practice sport during the twelve hours preceding this experiment. They were also instructed not to smoke, not to eat, and not to drink anything except water in the hour before the experiment. Finally, experimental sessions were conducted between 13:00 and 17:00 h and participants were instructed to wake up at least three hours before the beginning of the experiment to control the cortisol awakening response (Stalder et al., 2016).

Experimental design and procedure

Participants were brought into the gymnasium in groups of six, then a short static warm-up session of five free throws began. Each participant was in front of a basketball hoop and a scorer/ball boy was assigned to each player. Communication between players and with

Free-throw performance following acute stress

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the scorer was not allowed and comparing performance with other participants was not possible because they shot simultaneously in different directions. The first sequence (pre-TSST) consisted of 20 consecutive free throws with neutral instructions given by the experimenter, who was specifically trained before the beginning of the experiment with a specific text to memorize. All of the instructions were completely standardized and were given to the participants at the same time from one session to the next.

After the first sequence of 20 free throws, participants left the gymnasium for an adjacent room dedicated to the stress protocol. For approximately 25 minutes, the six participants of the session were exposed to the Trier Social Stress Test for Groups (TSST-G, Von Dawans, Kirschbaum, & Heinrichs, 2011), composed of both the preparation and delivery of a speech task simulating a recruitment interview and a mental arithmetic task in front of a committee of two absolutely neutral experimenters wearing white lab coats, seated behind a table on which a wide-angle video camera, a microphone, and a timer were placed. Participants were separated by mobile dividing walls that restricted visual and social interaction. After a 3-min preparation period, each participant performed the mock job interview for 2 min. Then the experimenters interrupted the first participant and requested the next one to speak (overall duration per group: 6 participants x 2 min = 12 min). The participants were not aware of the order in which they were being called. In the mental arithmetic task, each participant successively performed serial subtraction for 80 sec (duration: 6 participants x 80 sec = 8 min). To avoid learning effects, each participant received an individual starting number. The TSST-G was deliberately unrelated to the nature of the following free-throw task to investigate Hypothesis 1.

Once the TSST-G was completed, the six participants returned to the gymnasium to carry out the second sequence of 20 free throws (post-TSST) with the same organization as in the first sequence. The participants were blind to the objectives and the topic of the present

Free-throw performance following acute stress

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2
3 study. They were debriefed and thanked at the end of the experimentation. The full procedure
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5 is presented in Fig.1 and the experimental manipulation is presented below. This study was in
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7 line with the recommendations of the institutional board of the University and was conducted
8
9
10 in accordance with the Declaration of Helsinki.

11
12

Figure 1 near here

15 **Materials**

17 *Physiological stress response*

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19
20 In the vast majority of studies conducted with the TSST, salivary cortisol level was
21
22 used as the most relevant biological marker of stress (Allen et al., 2017). The saliva was
23
24 collected in plastic saliva collection tubes, five times: at baseline (T1 = -20 min before the
25
26 TSST-G), after the first sequence of free throws and before the TSST-G (T2 = -1 min), after
27
28 the TSST-G (T3 = +1 min), after the second free-throw sequence (T4 = +10 min), and finally
29
30 after a static recovery period (T5 = +15 min). The procedure was exactly the same as
31
32 precisely described in Mascret et al.'s (2016) study, with ELISA intra-assay variation of 4.7
33
34 $\pm 1.7\%$ and inter-assay variation of $6.1 \pm 3.6\%$ (using Salivary Cortisol Enzyme Immunoassay
35
36 Kit No. 1–3002, Salimetrics, UK).

38 *Psychological stress response*

39
40
41 State anxiety was assessed by two corresponding subscales of the French version of
42
43 the Competitive State Anxiety Inventory 2 Revised (CSAI-2R, Martinent, Ferrand, Guillet, &
44
45 Gauthier, 2010). Participants rated the intensity of each item on a scale of 1 (not at all) to 4
46
47 (very much so) to measure cognitive anxiety (e.g., “*I am worried about performing poorly*”)
48
49 and somatic anxiety (e.g., “*My hands are clammy*”). Cognitive and somatic anxiety were
50
51 assessed, twice: after the first sequence of free throws / before the TSST-G and after the
52
53 TSST-G. Internal consistency was satisfactory for pre- and post-TSST-G cognitive anxiety (α
54
55 = .78 and .85 respectively) and for post-TSST-G somatic anxiety ($\alpha = .84$), but surprisingly
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Free-throw performance following acute stress

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3 somewhat weak and questionable for pre-TSST-G somatic anxiety ($\alpha = .51$). All the
4
5 descriptive statistics of cortisol levels and cognitive and somatic anxiety scores are presented
6
7 in Table 1.
8
9

Table 1 near here

Perceived competition

16 To verify that the manipulation of competition was successful depending on the
17
18 condition (competition vs. no-competition), we used an adapted five-item version of the
19
20 questionnaire assessing the degree to which participants found the experimental setting to be
21
22 ego-involving (Sage & Kavussanu, 2007). For the purpose of this study, two of the seven
23
24 initial items were not relevant and were omitted. Responses were made for each item (e.g.,
25
26 “*In today’s experiment, winning was emphasized*”) on a five-point Likert scale from 1
27
28 (strongly disagree) to 5 (strongly agree). The subscale had high internal consistency ($\alpha = .93$).
29
30
31

Free-throw other-based goals

34 These were assessed one month earlier by the corresponding subscales of the 3x2
35
36 Achievement Goal Questionnaire for Sport (AGQ-S; Masciet et al., 2015). Participants
37
38 answered the three items assessing other-approach goals (e.g., “*When I shoot free throws, my*
39
40 *goal is to do better than others*”) and the three items assessing other-avoidance goals (e.g.,
41
42 “*When I shoot free throws, my goal is to avoid worse results than others*”) on a seven-point
43
44 Likert scale (1 = strongly disagree, 7 = strongly agree). Internal consistency was good for
45
46 other-approach goals ($\alpha = .92$) and other-avoidance goals ($\alpha = .93$).
47
48
49

Performance measurement

52 Participants performed two sequences of 20 free throws. Because performance
53
54 measurement was carried out simultaneously by the six players on six different basketball
55
56 backboards, the free-throw scoring of each player was manually documented on a score sheet
57
58 by an experimenter blinded to condition assignment who did not talk to the participant and
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Free-throw performance following acute stress

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3 who was specifically trained for this task. All the experimenters who collected the scores
4
5 were men and the instructions were completely standardized. Performance was defined as the
6
7 number of successful free throws in the pre- and the post-TSST.
8
9

10 ***Experimental manipulation***

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12 The experiment used a two-condition comparison design and participants were
13
14 randomly assigned to one of two conditions after the TSST-G: 19 participants in a
15
16 competition condition and 19 participants in a control condition (i.e., no-competition). To
17
18 induce competition in the second sequence of 20 free throws, the experimenter grouped the
19
20 participants before the first free throw and told them that from then on they were in
21
22 competition with one another and with other participants in the next sessions. The aim of the
23
24 competition was to be the best player, with the highest score, at the end of the 20 free throws.
25
26 They were also told that the complete ranking from first to last would be made accessible to
27
28 the public the next day and displayed in the gymnasium. Then, the players performed the
29
30 second sequence of 20 free throws. After the third, sixth, ninth, tenth, thirteenth, and
31
32 seventeenth free throws, the experimenter announced instructions aloud in order to maintain
33
34 the competition during the second sequence of 20 free throws (e.g., “*Ranking will be*
35
36 *displayed tomorrow*”). In the control condition, the coach announced the same neutral
37
38 instructions as before the first sequence of free throws. He also announced instructions aloud
39
40 exactly at the same times as in the competition condition, but these instructions were neutral
41
42 (e.g., “*There are ten free throws left*”).
43
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49 ***Data analysis***

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51 Repeated measures ANOVAs were conducted with Statistica 12 for PC on the results
52
53 of cortisol levels, cognitive anxiety, somatic anxiety, and performance scores to reveal
54
55 possible effect of Condition and Time of assessment. Following Lautenbach et al.’s (2014)
56
57 procedure, we calculated a baseline for cortisol levels as the mean of the first two measures
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Free-throw performance following acute stress

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(Pre-TSST = T1 and T2) and we computed the average of the cortisol response to the stress induction (Post-TSST = T3, T4, and T5). Level of significance was defined as $p < .05$. Partial eta-squared (η_p^2) was used to calculate effect sizes and Newman-Keuls tests were used to evaluate differences post-hoc. Finally, multiple regression analyses were conducted to examine how pre-TSST performance, other-approach goals, and other-avoidance goals predicted post-TSST performance for the two conditions (Competition, Control).

Results

Preliminary results

Physiological stress response

For salivary cortisol levels, a repeated measures ANOVA with the factors Time of assessment (Pre-TSST, Post-TSST) and Condition (Competition, Control) revealed a significant effect of Time ($F(4, 144) = 40.65, p < .001, \eta_p^2 = .53$) and a significant Time X Condition interaction ($F(4, 144) = 7.31, p < .001, \eta_p^2 = .17$). No significant effect was found for Condition ($p = .965$). Newman-Keuls post-hoc tests showed that cortisol levels were significantly higher ($p < .001$) after the TSST-G than before for both the competition and control conditions. No significant differences were found between competition and control conditions in pre- and post-TSST.

Psychological response to stress

For state anxiety scores, two consecutive repeated measures ANOVAs conducted respectively on cognitive and somatic anxiety scores with the factors Time of assessment and Condition revealed a significant effect of Time for cognitive anxiety ($F(1, 36) = 29.12, p < .001, \eta_p^2 = .45$) and somatic anxiety ($F(1, 36) = 22.27, p < .001, \eta_p^2 = .38$). No significant effects of Condition and Time X Condition interactions were found for cognitive anxiety ($p = .803$ and $p = .888$, respectively) and somatic anxiety ($p = .764$ and $p = .804$, respectively). Newman-Keuls tests showed that the cognitive and somatic anxiety scores were significantly

Free-throw performance following acute stress

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higher after the TSST-G than before for both the competition and control conditions (with p s ranging from .001 to .009). The three previous manipulation checks (cortisol levels, cognitive anxiety scores, somatic anxiety scores) evidenced that the TSST-G had indeed induced stress responses at the physiological and psychological levels. Table 1 presents the descriptive statistics for each variable.

Perceived competition

A one-way ANOVA conducted on the perceived competition scores showed a significant effect of Condition ($F(1, 36) = 9.53, p = .004, \eta_p^2 = .21$). Newman-Keuls tests evidenced that perceived competition was significantly higher ($M = 3.99, SD = 1.12$) for the competition group compared with the control group ($M = 2.89, SD = 1.06, p = .004$). The manipulation of competition was also successful.

Other-based goals

Two one-way ANOVAs did not reveal differences between the two experimental groups as regards their other-approach goals ($p = .827$) and their other-avoidance goals ($p = .759$).

Main results

Free-throw performance

A repeated measures ANOVA conducted on the free-throw performance scores with the factors Time and Condition revealed a significant effect of Time ($F(1, 36) = 5.26, p = .028, \eta_p^2 = .13$) and a significant Time X Condition interaction ($F(1, 36) = 5.26, p = .028, \eta_p^2 = .13$). Newman-Keuls tests showed that (1) there was no significant difference of performance on pre-TSST between the two experimental conditions ($p = .529$); (2) free-throw scores in the competition condition remained, surprisingly, exactly the same between the pre-TSST and the post-TSST sequences ($p = 1$); and (3) free-throw performance in the control condition significantly decreased between the pre- and the post-TSST ($p = .013$). We were

Free-throw performance following acute stress

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3 initially surprised by the descriptive statistics of the competition condition, in particular by the
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5 fact that the means and the standard deviations were identical before and after the TSST-G.
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7 However, if the means and standard deviations are effectively the same, the individual results
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9 are not at all identical. An inspection of the raw data showed that the post-TSST-G
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11 performance of each of the 19 participants increased or decreased relative to their pre-TSST-G
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13 performance.
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17 Detailed results of free-throw performance are presented in Table 1 above.

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19 Consequently, Hypothesis 1 was supported: free-throw performance decreased in the control
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21 condition following the TSST.
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23 24 *Regression analyses*

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26 We conducted regression analyses to examine how condition and other-based goals
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28 predicted post-TSST performance in the two conditions. Pre-TSST performance was also
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30 entered in the regression analyses, because post-TSST performance may be related with pre-
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32 TSST performance due to individual differences on initial free-throw performance between
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34 participants during the experimentation. Table 2 shows the results of this analysis for the two
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36 experimental conditions. As expected, pre-TSST performance was a significant positive
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38 predictor of post-TSST performance for the two conditions. Results mainly highlighted that
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40 other-approach goals were significant positive predictors of post-TSST performance in the
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42 competition condition but not in the control condition, which supported Hypotheses 2 and 3,
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44 respectively.
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Table 2 near here
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52 53 **Discussion**

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55 This study investigated the influence of competition on free-throw performance after
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57 an acute psychosocial stress induction through an experimental stress paradigm, the TSST,
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59 unrelated to the specific sport task. The TSST effectively induced significant stress responses
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3 on the psychological (increases of cognitive and somatic anxiety) and physiological (increases
4 of salivary cortisol levels) levels. The results first showed that free-throw performance
5 decreased for the control condition (i.e., only the TSST), despite the facts that the TSST is not
6 a specific sport task and that performance in competitive sports needs to be delivered within a
7 threatening and stress-inducing environment. Two main models have been used to study the
8 relationships between one of the stress psychological response, namely anxiety, and
9 perceptual-motor performance (Nieuwenhuys & Oudejans, 2012). Distraction models point
10 out that anxiety draws attention towards task-irrelevant stimuli and consequently attention to
11 movement execution is impaired. Finally, movement may be less accurate and may cause
12 poor performance. Execution focus models point out that anxiety may lead athletes to
13 explicitly control or monitor their movements. This may disrupt movement execution, which
14 is often automatized with experienced athletes, and, ultimately, may result in performance
15 decreases. In the present study, participants performed stereotyped free-throw movements,
16 performed a standardized performance task, and were all basketball players in clubs at
17 departmental to regional levels. Discrepancies in the findings were found between the present
18 study and Mascaret et al.'s (2016) study, in which the TSST did not impair free-throw
19 performance and movement execution of beginners. In our study, anxiety may have
20 negatively influenced both attention to relevant stimuli and overall automatization of the free-
21 throw movement of participants who have a more automatized movement than beginners,
22 which may account for the decline in performance following the TSST and may explain this
23 difference with Mascaret et al.'s (2016) results.

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Stress psychological and physiological responses to competition were found in
previous studies (Hogue et al., 2013, 2017). In the present study, free-throw performance
remained stable between pre-TSST and post-TSST when competition followed the TSST.
Psychosocial stress may be offset by the fact that situationally induced other-approach goals

Free-throw performance following acute stress

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3 often cause better performance (Van Yperen et al., 2014). Other-approach goals have been
4 shown to be associated with challenge-based affect, cognition, and behavior that tends to
5 facilitate performance (Murayama & Elliot, 2012). Effort and persistence are caused by
6 challenge appraisal when individuals are focused on the possibility of success comparatively
7 to others, and subsequently benefit performance attainment. Indeed, there is a greater
8 tendency to produce an active coping response pattern if the competitive situation is
9 considered a challenge, important for the participant, controllable, and depending on effort
10 (Salvador, 2012). Competition used in the present study may be regarded as explicitly
11 challenging (to be the best free-throw shooter), important (the ranking is displayed in the
12 gymnasium), controllable (the free-throw performance depends on the player), and dependent
13 on effort (if the player is at his best, he can expect to win the competition).
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28 Our results also showed that this is essentially the case for participants with high
29 levels of dispositional other-approach goals when they are placed in a competition after the
30 TSST. While experimental instructions inducing situational achievement goals often override
31 personal goals in affecting outcomes (Ntoumanis & Biddle, 1999), this study evidenced that
32 the combination of competition and dispositional other-approach goals led to a positive
33 outcome concerning free-throw performance following psychosocial stress. Results
34 highlighted that other-approach goals were significant positive predictors of post-TSST
35 performance in the competition condition but not in the control condition. The effect of other-
36 approach goals on the outcome variable was stronger in the condition that exacerbates these
37 goals than in the control condition (Ntoumanis et al., 2009). Participants with a dispositional
38 tendency toward competition (i.e., high levels of other-approach goals) may be more
39 concerned to demonstrate normative competence than others in a competition and may feel
40 comfortable in this specific climate despite their high levels of stress responses previously
41 induced by the TSST. While maintaining a high level of self-confidence is more difficult in
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Free-throw performance following acute stress

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3 competitive conditions (Kavussanu & Roberts, 1998), it may be easier for stressed players
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5 who have high levels of other-approach goals. This assumption derives from the idea that
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7 high levels of self-confidence may have a potential role in protection against the debilitating
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9 effects of anxiety (Hanton et al., 2008). This kind of stress-buffering effect may be considered
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11 because dispositional orientations have already been found to influence stress-buffering
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13 effects (e.g., dispositional affects, Janicki Deverts et al., 2017). But this assumption remains
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15 speculative and needs further investigations.
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20 In the competition condition, other-avoidance goals were not found to be significant
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22 predictors of post-TSST performance. The review by Lochbaum and Gottardy (2015)
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24 surprisingly evidenced that other-avoidance goals were mainly beneficial to performance in a
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26 laboratory setting and detrimental in a naturalistic setting. Even if the participants in this
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28 study effectively performed free throws, they were not placed in the context of a match or an
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30 official competition with teammates and opponents, and in front of an audience of supportive
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32 or hostile fans. Moreover, the participants were all young adults, and other-avoidance goals
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34 showed no effect on objective performance with samples aged 18 or above (Lochbaum &
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36 Gottardy, 2015). They are also competitive basketball players. The results would certainly be
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38 different in another achievement setting such as Physical Education, in which participation is
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40 mandatory and students are not necessarily interested in physical activity. In this specific
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42 context, other-avoidance goals may be negative significant predictors of post-TSST
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44 performance in such a competitive condition. But this hypothesis needs to be tested.
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50 Two main practical implications of this study may be envisaged. First, the present
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52 study showed that a stress-buffering effect may occur in competitive situations for athletes
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54 with high other-approach goals, leading to performance improvement despite initial
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56 psychosocial stress. If a coach knows that one of his athletes follows other-approach goals
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58 (focused on doing well relative to others), he should not hesitate to use competitive
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Free-throw performance following acute stress

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3 interventions (e.g., promoting comparison, emphasize ranking) during training and/or official
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5 competition to help the athlete to cope with stress and to expect a beneficial effect on
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7 performance. In sum, this may be useful for coaches who can adapt their interventions to the
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9 athletes' achievement goals when the environment is stressful. For example, a coach could
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11 specifically emphasize competition and comparison for a basketball player with high levels of
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13 other-approach goals when he performs two free throws in the final seconds of very close
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15 games, in order to increase the likelihood of scoring despite the stressful situation. Second,
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17 the results showed that a coach may induce psychosocial stress with experimental stress
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19 paradigms which are not directly sport-related. With two unknown tasks, the TSST may bring
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21 novelty into the training process when a coach wants to confront athletes with stressful
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23 situations, especially with athletes for whom competition during training is no longer
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25 sufficient to induce significant stress responses.
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31 Our results must, however, be considered with caution because they concern only
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33 other-approach goals and are context-specific through a free-throw task performed in an acute
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35 state of stress by trained young men. Moreover, this study is not without limitations. First, it
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37 focused on competition because we wanted to examine the relations between competition
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39 following an acute state of stress, other-based goals, and performance. Based on the literature
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41 review of Harwood et al. (2015), it could be promising to test the same hypothesis with
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43 stressed players faced with a complete performance climate (in which outperforming others,
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45 ranking, and rewards are emphasized) and a mastery climate (in which self-improvement and
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47 individual effort are valorized). In the absence of a previous stress, a mastery climate has
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49 positive relations with sport performance and is less likely to produce psychological and
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51 physiological stress responses (Hogue et al., 2013, 2017). Second, the influence of other
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53 achievement goals on post-TSST performance may be investigated. Task-approach goals
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55 (satisfying the absolute demands of the task) and self-approach goals (improving relative to
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Free-throw performance following acute stress

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3 own's trajectory) may have a protective role against the debilitating effects of acute stress
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5 because these kinds of goals are positively associated with performance attainment in the
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7 sport domain (Van Yperen et al., 2014). Third, all the participants in the present study were
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9 men because women's cortisol levels could have been influenced by menstrual cycle and/or
10
11 oral contraceptives (Allen et al., 2017). Because men often show higher competitive
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13 orientation than women, it could be interesting to replicate our study to elucidate how women
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15 react to competition following an acute stress. The continuation of interdisciplinary studies in
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17 the sport context is required to protect athletes from the debilitating effects of stress responses
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19 on sport performance, but also on their physical and mental health (Rimmele et al., 2007).
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Free-throw performance following acute stress

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Declaration of interest

No authors have competing interests

For Peer Review

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Table 1. Descriptive statistics of physiological, psychological, and behavioral measures.

Variables	Before the TSST-G		After the TSST-G	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Cortisol levels in nmol/L (manipulation check)				
Competition	8.25	3.02	11.00	2.56
Control	6.71	4.07	9.92	5.17
Cognitive anxiety (manipulation check)				
Competition	1.68	0.62	2.09	0.87
Control	1.64	0.46	2.03	0.72
Somatic anxiety (manipulation check)				
Competition	1.27	0.22	1.65	0.54
Control	1.29	0.30	1.71	0.68
Free-throw performance				
Competition	11.42	4.25	11.42	4.25
Control	12.26	3.75	9.63	4.27

Notes. *M* = Mean, *SD* = Standard deviation.

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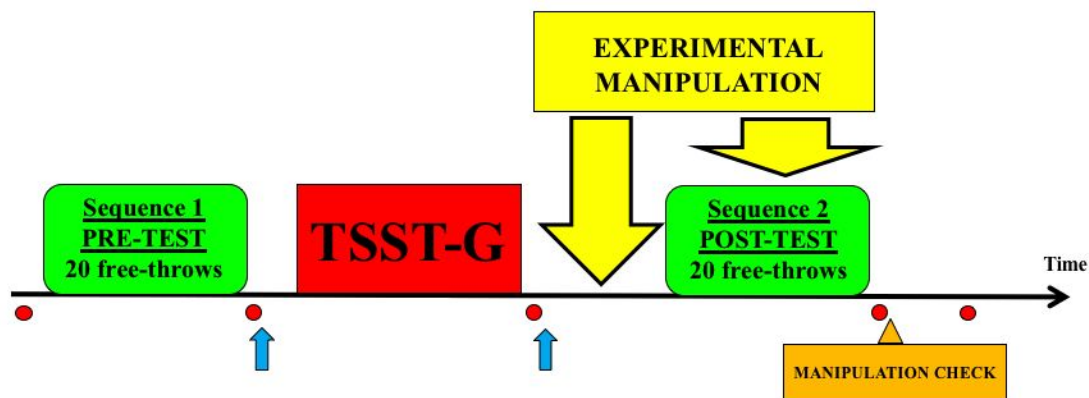
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Table 2. Regression analyses to examine other-approach goals and other-avoidance goals in predicting post-TSST performance in competition and control conditions, after controlling for pre-TSST performance.

	Post-TSST performance (competition condition)		Post-TSST performance (control condition)	
	R^2	β	R^2	β
Pre-TSST performance	.685***		.692***	
Other-approach goals		.58**		.78***
Other-avoidance goals		.69***		.14
		-.05		-.04

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Figure 1. Study design including timing of saliva sampling for cortisol measurements, completion of questionnaires, and free-throw performance.



Note. Circles are the moments of saliva collection; arrows are the moments of the completion of the scales assessing cognitive and somatic anxiety.