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7 Multidimensional Perfectionism and Cortisol Stress Response in Non-Clinical Populations: A
8 Systematic Review and Evaluation

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1 Abstract

2 The purpose of the study was to conduct a systematic review and evaluation of
3 research examining multidimensional perfectionism and cortisol in non-clinical populations.
4 A literature search yielded 6 studies examining cortisol reactivity (CR) and 2 studies
5 examining cortisol awakening response (CAR). Each study was rated in terms of the
6 methodological quality and evidence for the relationship between dimensions of
7 perfectionism (perfectionistic strivings, PS, and perfectionistic concerns, PC) and cortisol
8 was recorded. For CR, 1 study was rated as low methodological quality, 1 study was rated as
9 medium methodological quality, and 4 studies were rated as high methodological quality. Of
10 the high-quality studies, one study provided supportive evidence of a positive relationship
11 between PC and CR, and a further 3 provided inconclusive/null evidence. The only high-
12 quality study to examine the relationship between PS and CR provided inconclusive/null
13 evidence. For CAR, 1 study was rated as low methodological quality and the other as
14 medium methodological quality. Based on these findings, no firm conclusions can be drawn
15 regarding the relationship between perfectionism and cortisol. Moreover, if research
16 continues in the same vein, future research is unlikely to examine the relationship
17 appropriately. We therefore recommend future research follows expert guidelines regarding
18 assessing cortisol responses.

19

20 *Keywords:* perfectionism, cortisol, CAR

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1 Multidimensional Perfectionism and Cortisol Stress Response in Non-Clinical Populations: A
2 Systematic Review and Evaluation

3 **1. Introduction**

4 The experience of stress is a normal and important part of healthy functioning.
5 However, too much stress is known to contribute to ill-health (Schneiderman, Ironson, &
6 Siegel, 2005). Research suggests that some people are more prone to stress than others. In
7 regard to why this is the case, personality factors are thought to play an important part.
8 Research has found, for example, that being more perfectionistic is related to the experience
9 of higher levels of psychological stress (Flett, Nepon, Hewitt, & Fitzgerald, 2016) and stress
10 related ill-health (Limburg, Watson, Hagger, & Egan, 2016). Some of this research has
11 illustrated these relationships using physiological markers of stress (e.g., Wirtz et al., 2007).
12 However, in actuality, there is considerable variability in methodologies adopted by studies
13 examining perfectionism and physiological stress. It is therefore difficult for researchers and
14 practitioners to assimilate research in this area. To do so, and provide a better indication of
15 the current state of knowledge regarding perfectionism and physiological stress, in the current
16 study we systematically review and evaluate research that has examined the relationship
17 between multidimensional perfectionism and cortisol responses (cortisol reactivity and
18 cortisol awakening response).

19 **1.1 Psychological and Physiological Stress**

20 A considerable amount of research has been dedicated to the study of stress. Broadly,
21 stress is understood in terms of how an individual's response to internal or external stimuli
22 manifest into a series of mental and physical effects (Lazarus, 1993). From a psychological
23 perspective, a stress response is characterised by the cognitive appraisal of threat in the
24 context of personally meaningful goals, intentions, or expectations, and subsequent coping
25 behaviour (Lazarus, 1999). From a physiological perspective, a stress response is

1 characterised by a disruption to the homeostatic state of the body and changes in the nervous,
2 cardiovascular, endocrine, and immune systems aimed at restoring homeostasis (O'Connor et
3 al. 2000). An immediate or acute stress response is essential to allow humans to survive and
4 thrive (Segerstrom & Miller, 2004). However, chronic exposure to acute stress can act as an
5 antecedent to ill-health (Schneiderman et al., 2005). For example, repeated exposure to stress
6 contributes to suppression of immunity (Segerstrom & Miller, 2004) and an increased risk of
7 a range of pathological conditions (e.g., insomnia, Basta et al., 2007; cardiovascular disease,
8 Dimsdale, 2008; obesity, Dallman et al., 2003).

9 When seeking to examine the stress response, researchers have typically measured it
10 using either psychometric instruments or physiological markers. Psychometric instruments
11 take the form of paper-and-pencil questionnaires that focus on self-reported cognitive
12 appraisals (e.g., perceived threat) or emotions (e.g., anxiety) involved in the stress process
13 (see Carpenter, 2015 for a review). There are a number of benefits to using psychometric
14 instruments to measure stress that help explain their popularity. In particular, they are cheap,
15 easily administered, non-invasive, and relatively easy to interpret. However, there are also a
16 number of limitations to using psychometric instruments. For example, questionnaires are
17 influenced by self-report biases (e.g. reporting in a manner considered more socially
18 desirable), distorted self-perceptions (e.g., over or underestimating personal qualities) and
19 cultural factors (e.g., differences in interpretation of socially derived concepts). In addition,
20 while psychometric instruments designed to measure stress have been found to correlate to
21 some physiological markers of stress (e.g., cortisol; Brown et al., 2012), they have been
22 found to be uncorrelated with others (e.g., changes in immunity; Segerstrom & Miller, 2004).

23 When physiological markers have been used to examine the stress response they have
24 typically focused on measures of cardiovascular function (e.g., blood pressure & heartrate
25 variability; Azam et al., 2015), inflammatory proteins (e.g., interleukin-6 & C-reactive

1 protein; Pilger et al., 2014) and hormones (e.g., testosterone & epinephrine; Thoma et al.
2 2012). There are a number of notable benefits to using physiological markers to measure
3 stress in comparison to psychometric instruments. For example, physiological markers
4 overcome the aforementioned issues associated with self-report measurement (self-report
5 biases, distorted self-perceptions, and cultural factors). Furthermore, the use of physiological
6 markers can provide more precise and reliable measurement of one's objective reactivity to
7 stressful experiences. Therefore, physiological markers provide more direct measurement of
8 the impact of stress on the body regardless of an individual's conscious experience of it.

9 One common and popular hormone that can be used to examine the stress response is
10 cortisol. Cortisol is produced by the hypothalamus-pituitary-adrenal (HPA) axis. Specifically,
11 as part of a stress response, the paraventricular nucleus of the hypothalamus secretes
12 corticotropin-releasing factor (CRH) and vasopressin. This in turn signals the pituitary gland
13 to secrete adrenocorticotropic hormone which then signals the adrenal glands to secrete
14 cortisol in the zona fasciculata (Pariante & Lightman, 2008; Smith & Vale, 2006). Once
15 released, cortisol is responsible for important stress-regulating processes, such as increasing
16 gluconeogenesis, vascular tone, and respiratory rate, and inhibiting general vegetative
17 functions such as digestion (Smith & Vale, 2006). In doing so, cortisol is indirectly preparing
18 the body for a fight or flight response. Cortisol is a particular good measure of the stress
19 response because it is abundant and can be measured easily via serum or saliva, with a high
20 degree of reliability (Poll et al., 2007). There are also established guidelines on the best
21 methods to use when collecting and analysing cortisol. These include when to measure it,
22 how to measure it, and what confounding factors need to be controlled for when measuring it
23 (Levine et al., 2007; Pruessner et al., 2003; Stalder et al., 2016). Again, this means that
24 cortisol is especially useful in terms of examining the stress response.

1 Cortisol is commonly measured as part of the stress process in two ways. The first
2 way is to measure cortisol as part of a response to an acute stressor (cortisol reactivity, CR).
3 When examining CR cortisol is typically quantified using either absolute or relative change
4 in cortisol compared to baseline following introduction of a stressor (Pruessner et al., 2003).
5 A review of research by Dickerson and Kemeny (2004) identified a number of factors
6 associated with increased CR. Based on their findings, tasks that are active performance
7 situations requiring immediate overt or cognitive responses (e.g., mental arithmetic), include
8 salient social-evaluative threat (e.g., performance could be negatively judged by others) or
9 are uncontrollable (e.g., completing impossible tasks, performing under time constraint, and
10 false feedback) are associated with particularly strong CR. Moreover, tasks that contain all
11 these elements, such as the commonly used Trier Social Stress Test (TSST), produce the
12 largest changes in CR and have the longest recovery times (i.e., return of cortisol levels back
13 to baseline).

14 The second way to measure cortisol is as part of the diurnal rhythm (cortisol
15 awakening response, CAR). CAR refers to the rapid increase of cortisol levels within 20 to
16 30 minutes in the morning immediately upon awakening (Fries et al., 2009). This process
17 occurs as part of the natural diurnal rhythm and is captured by the shape of the cortisol
18 secretion curve during the first hour upon awakening. Despite some uncertainty regarding its
19 exact function, current consensus is that heightened or lowered CAR represent maladaptive
20 neuroendocrine processes (Stalder et al., 2016). This is demonstrated by a number of reviews
21 that have confirmed the relationship between CAR and psychiatric and health-related
22 variables (e.g., Chida & Steptoe, 2009; Fries et al., 2009; Kudielka & Wüst, 2010). In terms
23 of factors that contribute to CAR, research suggests that on a single day CAR is determined
24 by both trait-like factors (e.g., positive affect) and state factors (e.g., anticipation of day

1 ahead), with a larger proportion of variance in CAR being explained by the latter (Stalder et
2 al., 2016).

3 **1.2 Multidimensional Perfectionism**

4 Both CR and CAR have been found to be related to personality and individual
5 differences (e.g., Brown et al., 2012; Chida & Steptoe, 2009; Oswald et al., 2006). One factor
6 that has been found to be related to both CR and CAR is perfectionism. Although a variety of
7 perfectionism models exist, it is typically understood to be a multidimensional personality
8 trait consisting of two higher-order dimensions: perfectionistic strivings (PS) and
9 perfectionistic concerns (PC) (Stoeber & Otto, 2006). As described by Gotwals et al. (2012),
10 PS capture self-oriented strivings for perfection and the setting of high performance
11 standards. By contrast, PC capture the negative reactions to imperfections and mistakes, and
12 the fear of negative social appraisal. These two broad dimensions encapsulate the core
13 features of perfectionism from different models and allows various approaches to be
14 understood as part of a single unified model (Hill, 2016).

15 Most studies examining the role of perfectionism in the stress response (with the few
16 exceptions outlined below) have done so using self-report questionnaires to measure stress.
17 This research has taken place across a wide range of settings including students (e.g., Flett et
18 al., 2007), athletes (e.g., Stoeber et al., 2007), and patients diagnosed with eating-disorders,
19 major depression, and obsessive-compulsive disorder (e.g., Sassaroli et al., 2008). In this
20 research, PS are typically negatively related or unrelated to stress (e.g., Stoeber, 2012;
21 Stoeber & Otto, 2006; Stoeber & Rambow, 2007). Conversely, PC are typically positively
22 related to stress (e.g., Dunkley et al., 2003; Luyten et al., 2011; Stoeber & Rennert, 2008).
23 These findings are indicative of research more widely that has found similar relationships
24 between the two dimensions of perfectionism and other stress-related factors. This includes
25 perceptions of threat and use of coping strategies (e.g., Dunkley et al., 2003).

1 A small number of studies have examined the relationship between multidimensional
2 perfectionism and cortisol stress response (e.g., Richardson, Rice, & Devine, 2014; Rimes et
3 al., 2014; Zureck et al., 2014). When reading this research, the use of a wide range of
4 methods is immediately apparent. It is also evident that some of these studies have not
5 employed many of the recommended procedures when measuring cortisol. McGirr and
6 Turecki (2009) for example, did not control for gender in their analysis when examining CR
7 (menstrual cycle stage and use of oral contraceptives is known to affect cortisol; Kudielka et
8 al., 2009). Similarly, Zureck et al. (2014) failed to measure CR between 21-40min after the
9 onset of the cortisol response (when cortisol is known to peak; Dickerson & Kemney, 2004)
10 and did not include a measure of AUC_g or AUC_i (the two measures of cortisol ubiquitous in
11 the field). Differences between studies in methodologies and apparent methodological
12 weaknesses may explain why there are inconsistent findings evident in research examining
13 the relationship between dimensions of perfectionism and CAR and CR. For example, PC has
14 been found to have both a positive relationship with CR (Wirtz et al., 2007), and no
15 relationship with CR (McGirr & Turecki, 2009). Consequently, to better understand the
16 relationship between multidimensional perfectionism and cortisol response, this area of
17 research would benefit from a formalised systematic review and evaluation of research that
18 has taken place.

19 **1.3 Present Study**

20 The purpose of the current study was to conduct a systematic review and evaluation
21 of published research examining the relationship between multidimensional perfectionism
22 and both CR and CAR in non-clinical populations. Based on the findings from existing
23 research examining the relationships between perfectionism and stress employing self-report
24 and physiological measures, it was hypothesised that there would be a (i) a negative

1 relationship between PS and both CAR and CR and (ii) a positive relationship between PC
2 and both CAR and CR.

3 **2. Method**

4 **2.1 Literature Search**

5 Computerised literature searches on Cochrane Library, Medline, PsychARTICLES,
6 PsycINFO, and Web of Science were conducted. The search terms were of “perfection*” (for
7 perfectionism, perfectionist, and perfectionistic) and “cortisol”. The search date was between
8 January, 1990 and December, 2016. In addition, the reference lists of retrieved articles from
9 this search were searched and any applicable research retrieved. The date of the search was
10 24th October 2017.

11 Studies were included in the review if they (i) measured perfectionism using self-
12 report scales that yielded numerical data, (ii) measured perfectionism in a multidimensional
13 manner, (iii) measured cortisol using a conventional method (e.g., via serum, saliva or urine),
14 (iv) did not focus only on clinical groups (e.g., chronic fatigue syndrome), (v) were published
15 in English, and (vi) were published in a peer-reviewed journal. The first author conducted the
16 initial screening of all articles. All retrieved papers were then checked by the second author.
17 Any uncertainties regarding whether a study should be included or excluded were discussed
18 between the authors and a joint decision was made regarding inclusion of each article.

19 **2.2 Assessing Methodological Quality**

20 As part of the evaluation of each study, the methodological quality was rated. Rating
21 was based upon the recommendations of Dickerson and Kemeny (2004), Fries et al. (2009),
22 Khoury et al. (2015), Kudielka et al. (2009), and Stalder et al. (2016). The recommendations
23 focused on the quality of protocols used, quality of measures used, and the degree to which
24 confounding variables were controlled. Studies were scored on a seven-point scale, with
25 points awarded when each of the following criteria were met: (i) it is reported that

1 participants are adults free from any psychological and/or physical clinical diagnosis, (ii)
2 gender was controlled for, a male only sample was used, or a female only sample was used
3 that also controlled for oral contraceptives and menstrual cycle phase, (iii) a valid and reliable
4 measure of multidimensional perfectionism was used¹, (iv) a measure of total cortisol output
5 or cortisol change was included (AUC_g or AUC_i), (v) data was reported in a manner that the
6 strength, direction, and statistical significance of the relationship with dimensions of
7 perfectionism could be determined (vi) for studies measuring CR a minimum sample of $N=40$
8 was employed, for studies measuring CAR a minimum sample of $N=174$ was employed for
9 AUC_i and $N=364$ for AUC_g ², (vii) when CR was measured it was done so in the afternoon
10 between 21 and 40 min after onset of the stressor, or when CAR was measured the time of

¹ The DEQ was included as a valid and reliable measure of multidimensional perfectionism (and did not exclude it as a measure of unidimensional perfectionism) as the main advocate of the use of this subscale in perfectionism work (Dunkley) has previously noted that the DEQ is an indicator of PC (“DAS perfectionism and DEQ self-criticism have been demonstrated more closely related to measures reflecting EC perfectionism than to measures reflecting PS perfectionism (e.g., Dunkley & Blankstein, 2000; Enns & Cox, 1999; Sherry et al., 2003) and to load on the same latent variable as other measured indicators of EC perfectionism (Dunkley et al., 2003; Powers, Zuroff, & Topciu, 2004)”; Dunkley, Blankstein, Masheb, & Grilo, 2006; p.79). This has been illustrated in Dunkley, Zuroff and Blankstein (2003).

² No recommendations for minimal sample size when examining CAR were found. Therefore, we conducted power analysis to estimate these ourselves. To do so, we used data reported by Hellhammer et al. (2007). Our logic was that as CAR varies from day-to-day, we would expect studies to be designed in a manner that would detect effects larger than what is typically seen on a day-to-day basis (here, the largest observed change in AUC_i and AUC_g reported by Hellhammer et al., 2007). For AUC_i , effect size estimate $r = .21$, $p < .05$, power = .80, sample size estimate = 174. For AUC_g , effect size estimate $r = .15$, $p < .05$, power = .80, sample size estimate = 364.

1 measurement was objectively recorded (e.g., using time-stamped collection swabs) and on at
2 least two days. Studies were either ranked as high (6-7 points), medium (4-5 points) or low
3 (0-3 points) in methodological quality. Table 1 shows the rationale for inclusion of each of
4 the seven criteria. Only studies rated as having high methodological quality were considered
5 when testing the hypotheses.

6 **3. Results**

7 The study selection process is presented in Figure 1. A total of 60 records were
8 identified through database searching. After duplicates were removed, 29 articles remained
9 and were screened. Of these records, four were excluded because they were not published in
10 a peer reviewed journal in English, two were excluded as they were not an empirical study
11 (one was a response article and the other was an article outlining the protocol of a future
12 study), and seven were excluded because they did not actually examine perfectionism and/or
13 cortisol (i.e., didn't measure perfectionism, cortisol or both). This resulted in 16 full-text
14 articles being evaluated for eligibility. Of these full-text articles, three were excluded as they
15 did not measure or include a valid and reliable measure of multidimensional perfectionism³,
16 four were excluded as they did not actually examine/report the relationship between
17 perfectionism and cortisol (i.e., did measure perfectionism and cortisol but didn't examine
18 their relationship as this was not part of the aims of the study), and two were excluded
19 because they focused only on clinical groups. This resulted in seven articles reporting eight

³ These three studies were excluded on the basis of the perfectionism measures used (Bühren et al., 2012; Manara, Manara, & Todisco, 2005; van Santen et al., 2011). Van Santen et al. (2011) used the Leiden Index of Depression Sensitivity (LEIDS-R; Van der Does, 2002) which is not a measure of perfectionism. Bühren et al. (2012) and Manara et al. (2005) used the Eating Disorder Inventory-2 (EDI-2; Schoemaker, Verbraak, Breteler, & van der Staak, 1997). This is a unidimensional measure of perfectionism.

1 studies being included in the review and assessed for methodological quality. Table 2 shows
2 the characteristic of the eight studies, the subsequent rating of methodological quality
3 outlined below, and whether each study provided supportive, contradictory, or inclusive/null
4 evidence of hypothesis (i) and (ii).

5 **3.1 Characteristics of the Included Studies**

6 Of the studies examining CR, all employed a TSST procedure to induce a stress
7 response. The timing of cortisol measurements in the TSST's typically included measurement
8 immediately before the stressor though to 60 minutes post-test. However, there were some
9 instances of extended time periods such as 40 minutes before (McGirr and Turecki, 2009)
10 and 90 minutes post-test (Richardson, Devise, & Rice, 2014). Of the studies examining the
11 CAR, both measured cortisol at 0, 15, 30, 45, and 60 minutes upon awakening (in addition to
12 several points throughout the day). In regard to cortisol parameters, with the exception of one
13 study examining CR (Zureck et al., 2014), all other studies examined AUC_g and/or AUC_i.

14 In terms of the samples used, in studies examining CR, two studies employed mixed
15 gender samples (Richardson et al., 2014; Zureck et al., 2014), one study employed a female
16 only sample (McGirr and Turecki, 2009), and three studies employed male only samples
17 (Wirtz et al., 2007, Wirtz et al., 2008, Wirtz et al., 2013). In terms of studies examining CAR,
18 one study employed a female only sample (Rimes et al., 2014) and one employed a male only
19 sample (Wirtz et al., 2007). The studies employed a range in sample sizes, with the largest
20 including 84 participants (Zureck et al., 2014), and the smallest containing 16 participants
21 (McGirr and Turecki, 2009).

22 In terms of the perfectionism instruments used, four different measures of
23 perfectionism have been used. Three studies used the Frost Multidimensional Perfectionism
24 Scale German (FMPS-d; Wirtz et al., 2007, Wirtz et al., 2008, Wirtz et al., 2013), one study
25 used the Frost Multidimensional Perfectionism Scale (FMPS; Zureck et al., 2014), one study

1 used the Child and Adolescent Perfectionism Scale (CAPS; Rimes et al., 2014), one study
2 used the Depressive Experiences Questionnaire (DEQ; McGirr and Turecki, 2009), and one
3 study used the Short Almost Perfect Scale (SAPS; Richardson et al., 2014). All eight studies
4 examined PC, with only three studies examining PS (Richardson et al., 2014; Rimes et al.,
5 2014; Zureck et al., 2014).

6 **3.2 Rating of Methodological Quality**

7 **3.2.1 CR**

8 Of the six studies examining CR, one study was rated as having low methodological
9 quality (Zureck et al., 2014). This study failed to report that participants were free from
10 psychological and/or physical clinical diagnosis (criteria i), and used a predominately female
11 sample, with no indication of controlling for gender related factors (criteria ii). This study
12 also displayed no clear indication of the use of AUC_g or AUC_i or of the strength and direction
13 of the relationship between perfectionism and cortisol (criteria iv and v). The study also
14 failed to capture the 21-40 min peak cortisol secretion window (criteria vii).

15 One study was rated as having medium methodological quality (McGirr & Turecki,
16 2009). This study employed a mixed gender sample, failing to control for gender related
17 factors (criteria ii), and employed a sample smaller than the minimum we identified (criteria
18 vi).

19 Four studies were rated as high methodological quality (Richardson et al., 2014;
20 Wirtz et al., 2007; Wirtz et al., 2008; Wirtz et al., 2013). Two of the high quality studies
21 (Richardson et al., 2014; Wirtz et al., 2008) did not make clear the strength, direction, and/or
22 statistical significance of the relationship between dimensions of perfectionism and cortisol
23 (criteria v). In the first of these two studies it was noted that the relationship between PC and
24 CR was not statistically significant but no other information was provided (Wirtz et al.,
25 2008). In the second of these two studies the relationship between perfectionism and CR was

1 noted as a trend (“...perfectionists trended lower...” pp.115; Richardson et al., 2014). The
2 two other high quality studies (Wirtz et al., 2007; Wirtz et al., 2013) achieved full scores on
3 methodological criteria rating.

4 **3.2.2 CAR**

5 Of the two studies examining CAR, one study was rated as low in methodological
6 quality (Rimes et al., 2014). This study failed to employ an adult sample (criteria i). The
7 study also used a mixed gender sample, failing to control for gender related factors in the
8 analysis of cortisol (criteria ii)⁴, employed a sample smaller than the minimum we identified
9 (criteria vi), and failed to employ objective measurement strategies across multiple days
10 (criteria vii).

11 One study was rated as having medium methodological quality (Wirtz et al., 2007).
12 This study employed a sample smaller than the minimum we identified (criteria vi) and failed
13 to employ objective measurement strategies across multiple days (criteria vii).

14 **3.3 Assessing Support for the Hypotheses**

15 Only studies rated as high methodological quality are used to test the hypotheses.
16 However, in the interest of completeness, we have briefly described the findings of all studies
17 in relation to the two hypotheses below.

18 **3.3.1 CR**

19 Of the high quality studies, one provided supportive evidence of a positive
20 relationship between PC and CR (Wirtz et al., 2007). The remaining three high quality

⁴ Whilst the study controlled for the proportion of participants to reach menarche and day of menstrual cycle between the healthy control and chronic fatigue syndrome groups, there appeared to be no control for these factors within either group in regard to the relationship between CAR and perfectionism.

1 studies provided inconclusive/null evidence of relationships between PS, PC, and CR
2 (Richardson et al., 2014; Wirtz et al., 2008; Wirtz et al., 2013).

3 The medium quality study (McGirr & Turecki, 2009) provided inconclusive/null
4 evidence of the relationship between PC and CR. The relationship between PS and CR was
5 not assessed in the study.

6 The low quality study (Zureck et al., 2014) provided inconclusive/null evidence of the
7 relationships between PS, PC, and CR.

8 **3.3.2 CAR**

9 The two medium quality studies provided inconclusive/null evidence of relationships
10 between PS, PC, and CAR (Rimes et al, 2014; Wirtz et al., 2007).

11 **4. Discussion**

12 This study provided the first systematic review of cortisol response and perfectionism.
13 We examined the relationship between both CAR and CR and multidimensional
14 perfectionism measures. It was hypothesised that there would be a (i) a negative relationship
15 between PS and both CAR and CR and (ii) a positive relationship between PC and both CAR
16 and CR. Only one high quality study was found to test the first hypothesis and the findings of
17 this study were unclear. Four high quality studies were found to test the second hypothesis.
18 The findings of one study was unclear and the others provided a combination of supportive
19 evidence ($k = 1$) and null/inconclusive evidence ($k = 2$).

20 **4.1 CR and Multidimensional Perfectionism**

21 Based on the amount and quality of current research, it is difficult to provide any firm
22 conclusions regarding the relationships between PS, PC, and CR. Only one high quality study
23 investigated PS and CR (Richardson et al., 2014). In addition, in this study the strength and
24 statistical significance of the relationship was not clearly stated. It was described as a trend.
25 To complicate matters further, the reported trend was for a combination of higher PS, with

1 and without higher PC, to be associated with lower CR in comparison to a combination of
2 lower PS and PC, and for a combination of higher PS with higher PC to be associated with
3 lower CR than a combination of higher PS and lower PC. The first part of this trend supports
4 hypothesis (i) but the second part of the trend is contradictory to what would be expected
5 given hypothesis (ii). Consequently, additional high quality research examining PS and CR is
6 needed before any firm conclusion can be drawn.

7 In regard to PC and CR, four high quality studies provided conflicting evidence as to
8 whether PC is positively related to CR. Two studies found no significant relationship (Wirtz
9 et al., 2008; Wirtz et al., 2013). One study did not indicate the strength and statistical
10 significance of the relationship clearly (Richardson et al., 2014). A final study found support
11 for the hypothesised positive relationship (Wirtz et al., 2007). The study that did not report
12 the findings clearly aside, the three studies by Wirtz and colleagues were almost identical in
13 terms of salivary measurement timing protocols, sample size and demographic features of the
14 sample, cortisol parameters (i.e., the use of AUC_i or AUC_g) and perfectionism instruments
15 used (the CMD sub-scale of the MPS-d). Such differences therefore do not account for the
16 contradictory findings.

17 One issue that might account for the differences, however, are the statistical analyses.
18 In particular, the two studies that provided null/inconclusive evidence are based on regression
19 analyses that include a wider number of control variables. All three studies controlled for age,
20 BMI and blood pressure, whereas Wirtz et al. (2008) and Wirtz et al. (2013) also controlled
21 for other psychological variables (e.g., over-commitment, role uncertainty, and depression). It
22 may be that PC is positively related to CR in these two studies but such variables account for
23 this relationship. However, it is not possible based on the information provided in the
24 published papers to determine if this is the case. This issue underscores the importance of
25 reporting bivariate correlations. While other analyses may be of more interest for the research

1 question in the study, bivariate correlations provide essential information for all studies and
2 are the basis from which additional analyses can be derived. This includes meta-analytical
3 reviews. At the moment, this type of review would be very difficult based on reporting
4 practices in this area.

5 **4.2 CAR and Multidimensional Perfectionism**

6 Unlike studies examining CR, there were no high quality studies for CAR.
7 Consequently, no conclusions regarding the relationship between CAR and multidimensional
8 perfectionism can be drawn. So, to address the absence of research and ascertain whether
9 dimensions of perfectionism are related to CAR, high quality research in this area is a
10 priority. It is also a priority because CAR is proving to be a useful tool in the assessment of
11 anticipatory stress response and clinical diagnoses (Fries et al., 2009). Moreover, recent
12 meta-analytical evidence has confirmed that PS and PC, though PC especially, are associated
13 with various psychopathologies (Limburg et al., 2016). An altered CAR would be a further
14 sign of the debilitating consequences of perfectionism and may even be an explanatory
15 mechanism for secondary issues associated with perfectionism such as physical ill-health.
16 Moreover, such research would be a notable departure from the use of self-report measures of
17 ill-health that are typically employed in this area.

18 One further interesting possibility is that while multidimensional perfectionism may
19 not predict CAR, it may predict *changes* in CAR. This is consistent with the notion that CAR
20 is indicative of an anticipatory stress response and has a large state component. In the context
21 of perfectionism, this may include a situation designed to challenge perfectionistic
22 individuals need to be perfect (e.g., the morning of an important performance). This is
23 important because recent research on perfectionistic reactivity highlights that perfectionists
24 may only have heightened response (e.g., behavioural, emotional, physiological, etc.) when
25 their need for perfection is challenged (Flett & Hewitt, 2016). Moreover, reviews of research

1 examining whether other personality characteristics predict CAR have provided modest
2 findings with characteristics such as neuroticism predicting only a small amount of variance
3 (Chida & Steptoe, 2009). Few studies of personality and CAR are prospective/longitudinal,
4 such research would therefore also be valuable in this regard.

5 **4.3 Methodological Quality**

6 The backdrop for these findings is the large range in quality of methods employed
7 across studies. Only four of the nine studies were rated as being high in methodological
8 quality. One of the most common weaknesses was the samples used, in terms of size and
9 gender related factors. This is a problem as cortisol response has been shown to differ across
10 age and gender (Fries et al., 2009; Kudielka et al., 2009), and underpowered samples reduce
11 the ability to detect relationships. This latter issue being exacerbated by, in some instances,
12 poor reporting and the absence of information required to calculate effect sizes. The second
13 most common weakness was the timing and/or objectification of cortisol measurements. This
14 is a problem because CAR samples that have not been objectively measured have been
15 shown to profoundly impact CAR estimates (Stalder et al. 2016). Similarly, failing to control
16 the measurement time of CR (i.e., failing to measure in the afternoon vs. morning) has been
17 shown to be equally important (Dickerson and Kemeny, 2004). In order to examine the
18 relationship between perfectionism and CR and CAR appropriately these methodological
19 weaknesses need to be addressed in future research.

20 **4.4 Additional Recommendations for Future Research**

21 Given the recent release of reviews and consensus statements regarding cortisol and
22 its measurement (e.g., Khoury et al., 2015; Stalder et al., 2016), new studies should consider
23 the criteria we have used to evaluate methodological quality when designing future work. In
24 addition, we provide two further recommendations below for such work. Note, that while we

1 have perfectionism in mind, our recommendations are also applicable to examining
2 personality traits more widely.

3 **4.4.1 Recommendation One: Measure Additional Biomarkers.** Salivary cortisol is
4 the gold standard indicator of HPA axis neuroendocrine responses. However, other salivary
5 stress biomarkers are available which may provide additional information about stress
6 reactivity and help corroborate findings. Saliva contains other steroid hormones as well as
7 digestive enzymes, antibacterial peptides, neurotransmitters and immune parameters (e.g.,
8 antibodies, cytokines) and there is a growing amount of evidence linking these molecules to
9 acute and chronic stressors (Bosch 2014; Ivković et al. 2015; Obayashi 2013). For example,
10 the steroid hormone, dehydroepiandrosterone (DHEA), similar to cortisol, is an index of the
11 HPA axis stress response found in saliva but is less susceptible to degradation and may
12 provide a more robust biomarker in future studies (Walker et al. 2017). Examining other
13 biomarkers may therefore afford a greater opportunity to assess the relationship between
14 personality and stress responses.

15 **4.4.2 Recommendation Two: Combine Biomarkers.** If assessing other biomarkers,
16 researchers should also consider doing so as part of multiple biomarkers. Measurement of
17 several biomarkers in combination is recommended to enhance predictive power, where for
18 example, DHEA/cortisol ratios (Walker et al. 2017) are expressed or both HPA and
19 sympathetic indices (e.g. cortisol + salivary α -amylase activity; McGirr & Turecki, 2009) are
20 both taken into consideration. Indeed, research by McGirr & Turecki (2009), included in this
21 review, found that subjects with high scores in self-critical perfectionism (a proxy of PC)
22 were not associated with increases in salivary cortisol but were significantly associated with
23 salivary α -amylase activity, thus emphasising the importance of measuring multiple stress
24 biomarkers.

25 **4.5 Limitations**

1 Our review has a number of limitations. One possible limitation was the use of
2 multiple subscales of multidimensional perfectionism measures as key indicators of PS and
3 PC. While this is common practice in perfectionism research (e.g., Stoeber & Otto, 2006),
4 differences in the use of measures may account for some variation between studies in regard
5 to their findings. There is evidence that subscales might make a difference. In the work
6 domain for example, two subscales that load onto PS (the personal standards subscale of the
7 FMPS and the high standards subscale of the APS-R) have shown differing relationships with
8 burnout (Comerchero, 2008; Taris et al., 2010). Therefore, our findings cannot be considered
9 to reflect any specific dimension of perfectionism, rather they are reflective of a set of
10 proxies of two higher order dimensions.

11 It is also noteworthy that how the relationships between dimensions of perfectionism
12 and cortisol were statistically analysed and reported made it difficult in some cases to assess
13 the findings regarding our hypotheses. Some studies included control variables in the
14 analyses and other did not. Some studies included only PC (yielding the unique effect of PC)
15 whereas others included PC and PS (yielding the unique effect of both in the presence of the
16 other). In addition, as noted earlier, often analyses were not reported in full and bivariate
17 correlations not reported. Inevitably, the conclusions we offer in our review are influenced by
18 the availability, quality and comparability of the analytical strategies employed in the
19 individual studies.

20 A further limitation is related to our focus only on non-clinical samples. This is
21 necessary as clinical diagnoses can influence cortisol and the exact influence can depend on
22 the specific diagnoses. The ramifications here are that our findings cannot be generalised
23 beyond a healthy population. Overall there are currently few studies that have examined the
24 relationship between perfectionism and cortisol responses in clinical populations ($k = 5$) and
25 the type of clinical diagnoses vary making comparison difficult (e.g., chronic fatigue

1 syndrome and anorexia nervosa; Kempke et al., 2016; Ward et al., 1998). More research is
2 required before this research can be explored in a meaningful manner.

3 Finally, our review included only published peer-reviewed journals and did not
4 include unpublished theses and dissertations. Including unpublished work can offset concerns
5 regarding publication bias. It is possible, then, that without including unpublished work the
6 current review over-represents studies that have found a relationship of some kind between
7 perfectionism and cortisol (i.e., there may be more unpublished studies that have produced
8 null/inconclusive findings).

9 **5. Conclusions**

10 The current study provides the first systematic review of the relationship between
11 perfectionism and cortisol stress response. Across studies it was found that there was both
12 supportive and null/inconclusive evidence of a relationship between cortisol response and
13 multidimensional perfectionism. Generally, few studies demonstrated high quality
14 methodologies. Subsequently, based on our review of research, no firm conclusions can be
15 drawn regarding the relationship between multidimensional perfectionism and cortisol
16 response. If research continues in the same vein, this relationship will not be examined
17 appropriately. Future research must therefore improve the procedures employed in line with
18 expert guidelines regarding measuring cortisol responses (e.g., Stalder et al., 2016).

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Conflict of Interest

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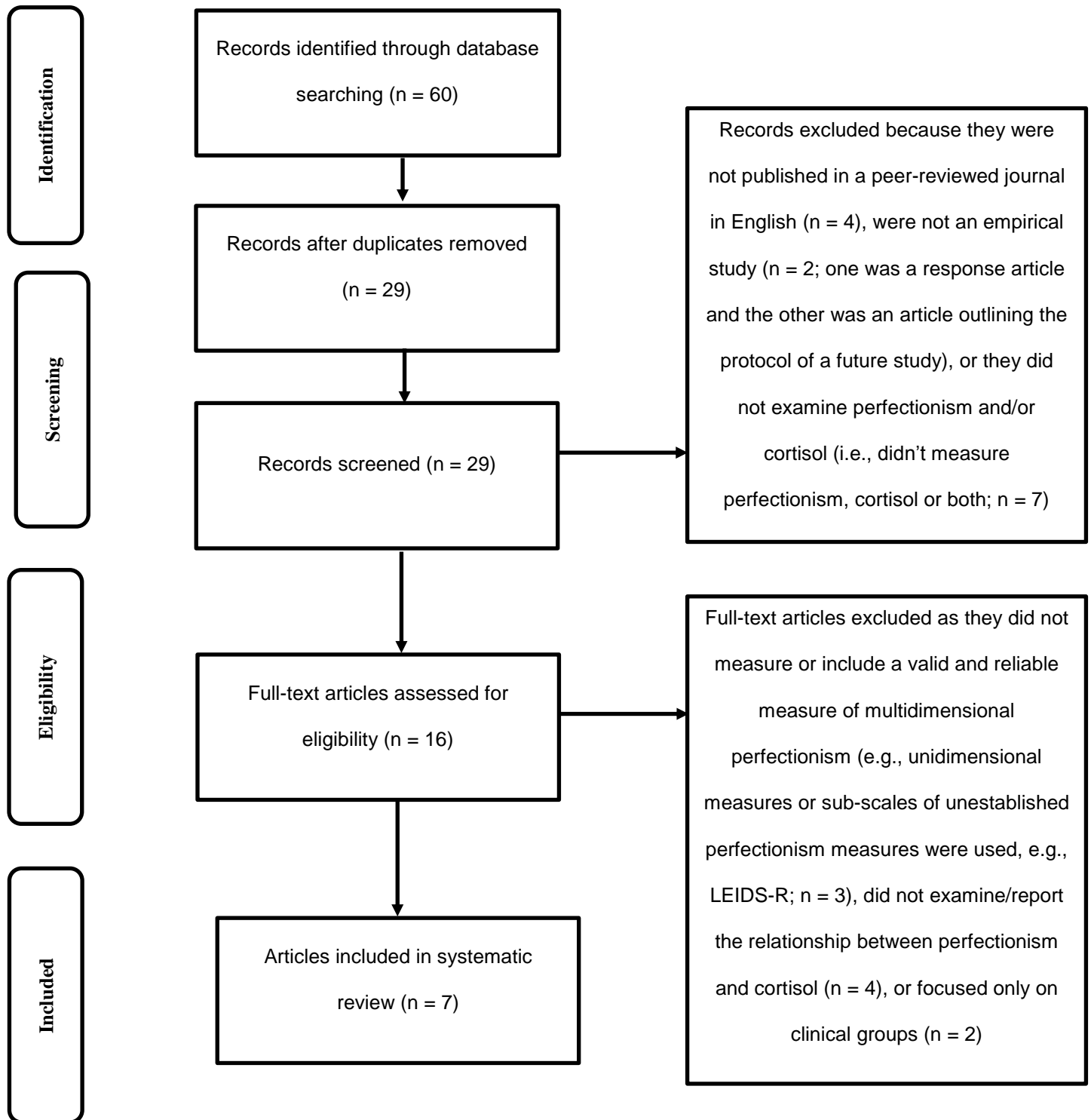


Figure 1. Flowchart of the search strategy and article selection process

Table 1. Criteria for assessing methodological quality of studies.

Criteria	Rationale
(i) It is reported that participants are adults free from any psychological and/or physical clinical diagnosis.	Psychological and physical clinical diagnosis affects cortisol (see Fries et al., 2009; Stalder et al., 2016).
(ii) Gender was controlled for, a male only sample was used, or a female only sample was used that also controlled for oral contraceptives and menstrual cycle phase.	Gender related factors affect cortisol including menstrual cycle stage and use of oral contraceptives (Kudielka et al., 2009).
(iii) A valid and reliable measure of multidimensional perfectionism was used.	We adopted the position that perfectionism is multidimensional based on the recommendations of researchers in this area (e.g., Stoeber & Otto, 2006) and factor analytical evidence of the higher-order structure of perfectionism (e.g., Stairs et al., 2012). Validity and reliability were assessed based on existing evidence on the instrument (e.g., whether there has been formal evaluation of the properties of the instrument and the results of the evaluation).
(iv) A measure of total cortisol output or cortisol change was included (AUC _g or AUC _i).	Research has found these two indicators to be the most suitable and reliable with regards to examining total cortisol and changes in cortisol (Khoury et al., 2015).
(v) Data was reported in a manner that the strength, direction, and statistical significance of the relationship with dimensions of perfectionism could be determined.	Good reporting practices were considered important so to allow assessment of the relationship between perfectionism and cortisol to be clearly discerned.
(vi) For studies measuring CR a minimum sample of $N=40$ was employed, for studies measuring CAR a minimum sample of $N=174$ was employed for AUC _i and $N=364$ for AUC _g .	When examining CR, a minimum of 40 participants is required for adequate statistical power (Dickerson & Kemeny, 2004). No recommendation exists for the CAR, our own power analysis was conducted for this study and identified $N=174$ for AUC _i and $N=364$ for AUC _g (see footnote 2).
(vii) When CR was measured it was done so in the afternoon between 21 and 40 min after onset of the stressor, or when CAR was measured the time of measurement was objectively recorded (e.g., using time-stamped collection swabs) and on at least two days.	When examining CR, cortisol peaks 21-40 minutes post stressor (Dickerson & Kemeny, 2004). Given the large state-like component of the CAR, it is advisable to measure it over two or more days (Stalder et al. 2016). In addition, delays to the beginning of sampling after awakening have been shown to be common and have a major impact on CAR and should therefore be noted (Stalder et al., 2016).

Table 2. Characteristics of studies included in the review and evaluation.

Article	Salivary Measurement Timing Protocol	Sample	Perfectionism Instrument	PS Sub-Scale	PC Sub-Scale	Cortisol Parameter	Quality of Methods Score	Methodological Point Allocation	Evidence of a Relationship	Hypothesis (i)	Hypothesis (ii)
CAR	0, 15, 30, 45 & 60 mins upon awakening (Between 06:00- 09:00), and 12:00, 16:00, & 20:00	<i>n</i> (HC) = 36. Females = 21. <i>M-age</i> = 15.0, <i>SD-age</i> = 1.7).	CAPS	Self-oriented	Self-oriented-Critical &	AUC _g	3	(iii), (iv), (v)	No	Null	Null
				Striving	Socially-prescribed	AUC _i	(low)			Null	Null
	0, 15, 30, 45 and 60 mins upon awakening and 8:00, 11:00, 16:00, & 20:00.	<i>n</i> = 50. All male. <i>M-age</i> = 42.5, <i>SD-age</i> = 14.1.	FMPS-d	-	Concern Over Mistake and Doubts	AUC _g	5 (medium)	(i), (ii), (iii), (iv), (v)	No	-	Null
	TSST: -40, -30, -20, -10, 0, 10, 2-, 30, & 40 (mins)	<i>n</i> = 16. Females = 10. <i>M-</i> <i>age</i> = 44.18, <i>SD-age</i> = 15.24.	DEQ	-	Self-Critical Perfectionism	AUC _i	5 (medium)	(i), (iii), (iv), (v), (vii)	No	-	Null
	TSST: 0, 10, 20, 30, 40, 50, 60, 70, 80, & 90 (mins).	<i>n</i> = 61. Students (29 men; 32 women; <i>M-age</i> = 18.88, <i>SD-age</i> = 1.91).	SAPS	Standards	Discrepancy	AUC _i	6 (high)	(i), (ii), (iii), (iv), (vi), (vii)	No	†	†
CR	TSST: Immediately before, 0, 10, 20, 30, 40, 50, & 60 (mins)	<i>n</i> = 50. All male. <i>M-age</i> = 42.5, <i>SD-age</i> = 14.1.	FMPS-d	-	Concern Over Mistake and Doubts	AUC _i	7 (high)	(i), (ii), (iii), (iv), (v), (vi), (vii)	Yes	-	Supportive
	TSST: Immediately before, 0, 10, 20, 30, 40, 50, & 60 (mins)	<i>n</i> = 58. All male. <i>M-age</i> = 36.3, <i>SD-age</i> = 13.7.	FMPS-d	-	Concern Over Mistake and Doubts	AUC _g	6 (high)	(i), (ii), (iii), (iv), (vi), (vii)	No	-	Null
	TSST: Immediately before, 0, 10, 20, 30, 40, 50, & 60 (mins)	<i>n</i> = 43. All male. <i>M-age</i> = 44.5, <i>SD-age</i> = 13.1.	FMPS-d	-	Concern Over Mistake and Doubts	AUC _i	7 (high)	(i), (ii), (iii), (iv), (v), (vi), (vii)	No	-	Null
	TSST: Immediately before, 10, 15, & 30 (mins)	<i>n</i> = 84. Students (21 men; 63 women; <i>M-age</i> = 23.94, <i>SD-age</i> = 4.81)	FMPS	Personal Standards	Concern Over Mistakes	Undefined	2 (low)	(iii), (vi)	No	Null	Null

Notes: CAR = cortisol awakening response; CR = cortisol reactivity; PS = perfectionistic strivings; PC = perfectionistic concerns; TSST = Trier Social Stress Test; HC = healthy controls; CAPS = Child & Adolescent Perfectionism Scale; FMPS(-d) = Frost Multidimensional Perfectionism Scale (German); DEQ = Depressive Experiences Questionnaire; SAPS = Short Almost Perfect Scale; AUC_g = Area under the curve [with respect to ground (g), increase (i)]; - = unexamined; † = no data.

^aThis study examined both healthy controls and participants with chronic fatigue syndrome, with only the former being included for examination in this review.