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

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Abstract

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

Keywords: perfectionism, cortisol, CAR

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1. Introduction

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

1.1 Psychological and Physiological Stress

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

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

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

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

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

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

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

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

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

1.2 Multidimensional Perfectionism

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

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

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

1.3 Present Study

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

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

2. Method

2.1 Literature Search

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

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

2.2 Assessing Methodological Quality

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

participants are adults free from any psychological and/or physical clinical diagnosis, (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, (iii) a valid and reliable measure of multidimensional perfectionism was used[1], (iv) a measure of total cortisol output or cortisol change was included (AUC_g or AUC_i), (v) data was reported in a manner that the strength, direction, and statistical significance of the relationship with dimensions of perfectionism could be determined (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 [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

[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.

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

3. Results

The study selection process is presented in Figure 1. A total of 60 records were identified through database searching. After duplicates were removed, 29 articles remained and were screened. Of these records, four were excluded because they were not published in a peer reviewed journal in English, two were excluded as they were not an empirical study (one was a response article and the other was an article outlining the protocol of a future study), and seven were excluded because they did not actually examine perfectionism and/or cortisol (i.e., didn't measure perfectionism, cortisol or both). This resulted in 16 full-text articles being evaluated for eligibility. Of these full-text articles, three were excluded as they did not measure or include a valid and reliable measure of multidimensional perfectionism[3], four were excluded as they did not actually examine/report the relationship between perfectionism and cortisol (i.e., did measure perfectionism and cortisol but didn't examine their relationship as this was not part of the aims of the study), and two were excluded 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.

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

3.1 Characteristics of the Included Studies

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

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

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

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

3.2 Rating of Methodological Quality

3.2.1 CR

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

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

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

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

3.2.2 CAR

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

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

3.3 Assessing Support for the Hypotheses

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

3.3.1 CR

Of the high quality studies, one provided supportive evidence of a positive 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.

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

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

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

3.3.2 CAR

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

4. Discussion

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

4.1 CR and Multidimensional Perfectionism

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

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

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

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

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

4.2 CAR and Multidimensional Perfectionism

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

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

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

4.3 Methodological Quality

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

4.4 Additional Recommendations for Future Research

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

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

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

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

4.5 Limitations

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

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

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

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

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

5. Conclusions

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

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Conflict of Interest

Conflicts of interest: none.

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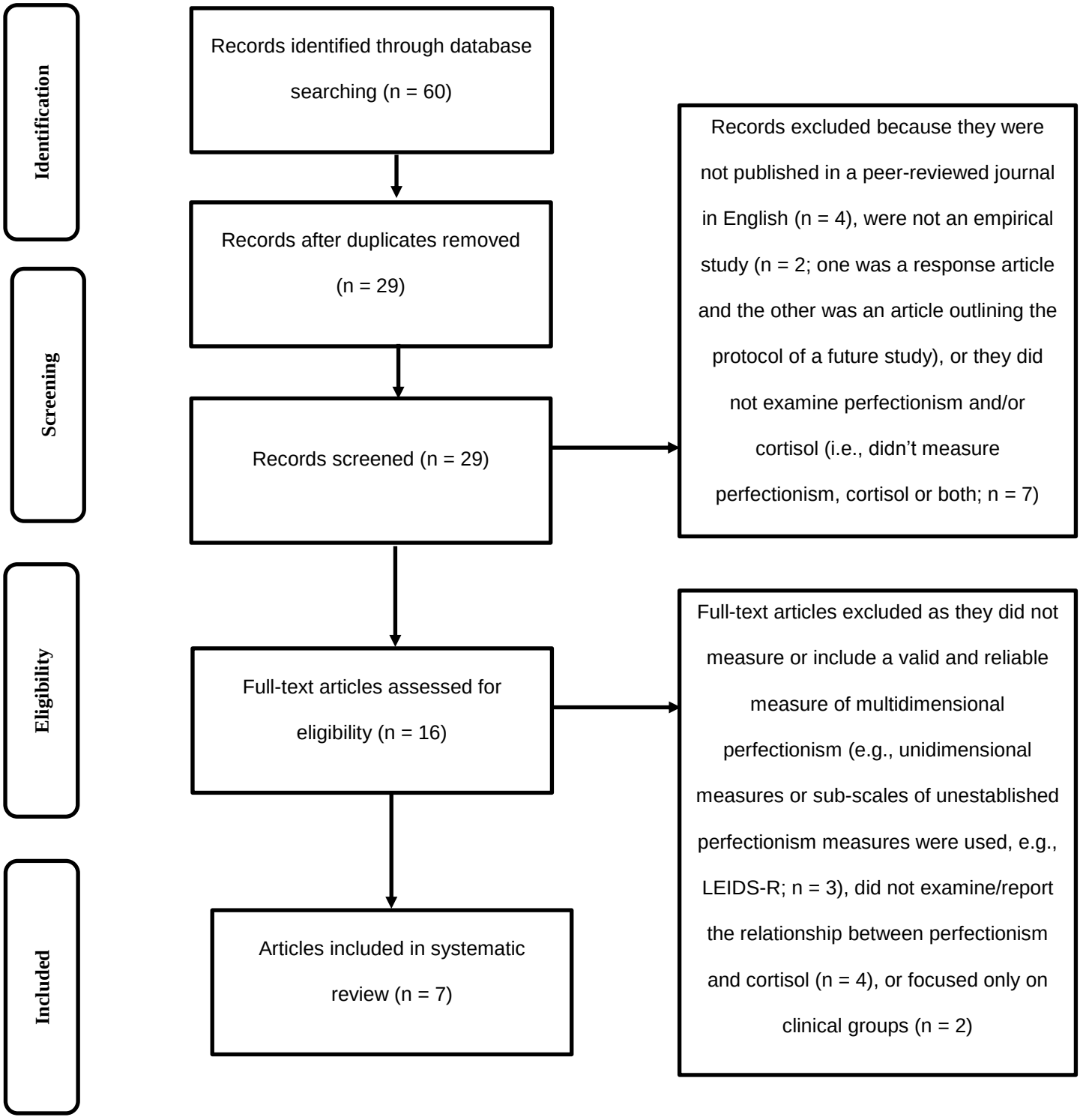

Figure 1. Flowchart of the search strategy and article selection process

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 AUCi and N=364 for AUCg (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	Rimes et al. (2014)[a]	0, 15, 30, 45 & 60 mins upon awakening (Between 06:00-09:00), and 12:00, 16:00, & 20:00	*n* (HC) = 36. Females = 21. *M-age* = 15.0, *SD-age* = 1.7).	CAPS	Self-oriented Striving	Self-oriented-Critical & Socially-prescribed	AUC_g AUC_i	3 (low)	(iii), (iv), (v)	No	Null Null	Null Null
	Wirtz et al. (2007)	0, 15, 30, 45 and 60 mins upon awakening and 8:00, 11:00, 16:00, & 20:00.	*n* = 50. All male. *M*-age = 42.5, *SD*-age = 14.1.	FMPS-d	-	Concern Over Mistake and Doubts	AUC_g	5 (medium)	(i), (ii), (iii), (iv), (v)	No	-	Null
CR	McGirr & Turecki (2009)	TSST: -40. -30, -20, -10, 0, 10, 2-, 30, & 40 (mins)	*n* = 16. Females = 10. *M*-age = 44.18, *SD*-age = 15.24.	DEQ	-	Self-Critical Perfectionism	AUC_i	5 (medium)	(i), (iii), (iv), (v), (vii)	No	-	Null
	Richardson, Rice, & Devine (2014)	TSST: 0, 10, 20, 30, 40, 50, 60, 70, 80, & 90 (mins).	*n = 61.* Students (29 men; 32 women*; M-age* = 18.88*, SD-age* = 1.91*).*	SAPS	Standards	Discrepancy	AUC_i	6 (high)	(i), (ii), (iii), (iv), (vi), (vii)	No	†	†
	Wirtz et al. (2007)	TSST: Immediately before, 0, 10, 20, 30, 40, 50, & 60 (mins)	*n* = 50. All male. *M*-age = 42.5, *SD*-age = 14.1.	FMPS-d	-	Concern Over Mistake and Doubts	AUC_i	7 (high)	(i), (ii), (iii), (iv), (v), (vi), (vii)	Yes	-	Supportive
	Wirtz et al. (2008)	TSST: Immediately before, 0, 10, 20, 30, 40, 50, & 60 (mins)	*n* = 58. All male. *M*-age = 36.3, *SD*-age = 13.7.	FMPS-d	-	Concern Over Mistake and Doubts	AUC_g	6 (high)	(i), (ii), (iii), (iv), (vi), (vii)	No	-	Null
	Wirtz et al. (2013)	TSST: Immediately before, 0, 10, 20, 30, 40, 50, & 60 (mins)	*n*= 43. All male. *M*-age = 44.5, *SD*-age = 13.1.	FMPS-d	-	Concern Over Mistake and Doubts	AUC_i	7 (high)	(i), (ii), (iii), (iv), (v), (vi), (vii)	No	-	Null
	Zureck et al. (2014)	TSST: Immediately before, 10, 15, & 30 (mins)	*n = 84.* Students (21 men; 63 women; *M*-age = 23.94, *SD*-age = 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; $AUC_{[]}$ = Area under the curve [with respect to ground (g), increase (i)]; - = unexamined; † = no data.

[a] This study examined both healthy controls and participants with chronic fatigue syndrome, with only the former being included for examination in this review.