Chapter 12
Physiological Correlates of Mental Well-Being

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Despite the rapidly growing interest in positive aspects of human functioning, the research on physiological correlates of mental well-being is still quite scarce. Comparing the extensive number of studies that delineate the physiological correlates of mental disorders with the modest number of studies that focus on physiological correlates of mental well-being, the lack of research that is physiologically oriented becomes particularly clear. This lack of knowledge of the physiological correlates of mental well-being results from research primarily focused on alleviating human suffering by detecting physiological changes linked to mental disorders and to tailoring effective medical treatment that target relevant physiological systems (e.g., Dockray and Steptoe 2010; Ryff and Singer 1998). However, recent research makes it clear that the absence of mental disorder does not necessarily equal mental well-being, as characterized by thriving and flourishing. Instead, mental functioning has turned out to be more complex, with some individuals who exhibit concurrent mental disorder and mental well-being, others who show no mental disorder but who demonstrate low levels of mental well-being, and still others who flourish and live meaningful and happy lives (Keyes 2002). Research on the linkages between bodily processes and mental well-being allows descriptions to be formatted of important similarities and differences between human functioning, in terms of mental disorder and mental well-being. Importantly, studies of the physiological correlates to mental well-being can help to clarify why some individuals maintain health during adversity, while others fall ill (cf. Ryff et al. 2006).

The purpose of this chapter is to offer a review of research that investigates the physiological underpinnings of mental well-being. The chapter starts out by providing a rationale for the study of physiological correlates of mental well-being. It then

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C.L.M. Keyes (ed.), *Mental Well-Being: International Contributions to the Study of Positive Mental Health*, DOI 10.1007/978-94-007-5195-8_12,

proceeds to provide a basic framework for understanding different physiological systems and related physiological indicators that have been included in empirical studies of mental well-being. The chapter then moves on to introducing common physiological indicators that have been included in empirical research on mental well-being. Having introduced basic physiology and having presented the two broad well-being orientations and their related definitions of mental well-being, the subsequent section describes and summarizes research on physiological correlates relating to three different aspects of mental well-being. The chapter ends with an integration of the field and suggestions for future research.

Why a Focus on Physiological Correlates?

Although the research on physiological correlates of mental well-being is scarce, an increasing number of studies show that positive psychological functioning is related to good physical health, reduced mortality, and longevity (Chida and Steptoe 2008; Cohen and Pressman 2006; Dockray and Steptoe 2010; Ryff and Singer 1998, 2008; Steptoe et al. 2009). In addition to research on factors pertaining to resilience, such as optimism (Seligman 1998) and sense of coherence (Antonovsky 1985, 1987), positive affective states have been more consistently linked to various physical health outcomes (for reviews, see Pressman and Cohen 2005; Cohen and Pressman 2006; Steptoe et al. 2009). A now classic example is the longitudinal study of catholic nuns by Danner et al. (2001), which showed that positive emotional content expressed in writing by nuns in their early twenties was inversely associated with risk of mortality 60 years later. These relationships between various types of positive psychological functioning and physical health outcomes are likely to be coupled with physiological processes (e.g., Ryff and Singer 1998; Steptoe et al. 2005). This assumption also draws on the fact that mental disorders, apart from deteriorating psychological functioning, most often involve physiological changes reflected in deviations at the neurophysiological, hormonal, or other bodily levels (Ganzel et al. 2010; McEwen 2007). With this in mind, delineating how mental well-being relates to physiology will advance the knowledge of health-promoting and protective bodily processes.

When it comes to explaining the nature of the relationships between positive psychological functioning and physical health, different mechanisms have been suggested (Pressman and Cohen 2005; Ryff and Singer 1998; Steptoe et al. 2005). Among these are mechanisms including behavioral and psychobiological processes, respectively. A mechanism focusing on behavioral factors suggests that mental well-being may be coupled with health-promoting behaviors, including a healthy lifestyle, which, in turn, promote better physical health. According to mechanisms including psychophysiological processes, the interaction between mental well-being and physical health involve psychobiological processes, including various bodily systems and their functioning, which, in turn, influence physical health.

Physiological Indicators

Physiological indicators can be used to investigate bodily functioning and health-related outcomes. Considering that the brain plays a central role in interpreting, evaluating, and responding to daily life challenges and demands, central physiological processes relating to an individual's interpretation, evaluation, and response to situations in daily life reverberate through the body, which, in turn, signal back to the brain. This means that there is a constant ongoing interaction between central and peripheral processes that is reflected in central and peripheral physiological activity (e.g., Ganzel et al. 2010; McEwen 2007). From this, physiological indicators can be measured at different levels (McEwen and Seeman 1999). In describing the different levels of physiological correlates, it is useful to distinguish between peripheral and central indicators. While central indicators reflect central functioning in terms of brain activity, peripheral indicators reflect physiological functioning in the rest of the body (Ganzel et al. 2010). Since valid assessment of central indicators typically requires careful measurements using technically advanced and sophisticated equipment, the assessment of central indicators is commonly restricted to the laboratory setting. In contrast, the development of portable devices has facilitated the assessment of peripheral indicators reflecting, for instance, cardiovascular functioning in different settings, including situations in daily life and controlled experimental settings (Andreassi 2006). Other peripheral indicators, for instance, that assess functioning within the endocrine system are commonly measured in blood, saliva, or urine. These indicators can thus be measured in different settings, including both laboratory and daily life settings. Also the use of saliva and urine for the assessment of physiological indicators is noninvasive, which allows for intensive repeated sampling over time without causing any harm to study participants (Lundberg 2005). Among the commonly studied peripheral physiological indicators are physiological indicators that reflect activity within the cardiovascular, endocrine, metabolic, and immune systems. Physiological indicators from these different systems have independently and together been linked to various health outcomes (Ganzel et al. 2010; McEwen and Seeman 1999).

The cardiovascular system consists of the heart, systemic circulation, and pulmonary circulation with the primary function of supplying blood and transporting oxygen, nutrients, and other substances to different bodily organs and tissues (e.g., Andreassi 2006). The cardiovascular system is influenced by activity within the sympathoadrenomedullary (SAM) system, which involves brain mechanisms and plays a central role in physiological arousal. Commonly assessed indicators of the functioning of the cardiovascular system include systolic and diastolic blood pressure and heart rate. Increased levels of blood pressure and heart rate have repeatedly been associated with adaptive responses to acute challenges and demands. However, chronically high levels of cardiovascular activity, such as high blood pressure, have been identified as a risk factor for physical ill health and disease.

Apart from influencing activity within the cardiovascular system, the SAM system influences the endocrine system and the release of the catecholamines adrenaline and noradrenaline. Both adrenaline and noradrenaline are secreted peripherally into the blood by the adrenal medulla and then circulated around the body. Besides catecholamines, there is another set of endocrine markers: glucocorticoids. Glucocorticoids are released peripherally into the blood from the adrenal cortex upon activation of the hypothalamic-pituitary-adrenal (HPA) axis. Cortisol is one of the most important and well-researched glucocorticoids, and cortisol receptors are found in all major organs and bodily tissues. This means that cortisol can have a major impact on bodily functioning. By stimulating the peripheral release of endocrine markers, the central mechanisms of the SAM system and the HPA axis trigger a set of coordinated physiological changes that have an adaptive function and increase an individual's readiness to respond to and act on challenges or demands in the environment. Such acute physiological changes are adaptive. In contrast, long-term physiological activity, characterized by chronic changes in endocrine activity, has been associated with bodily wear and tear. Cortisol, in particular, has diversified short-term and long-term effects on bodily functioning with chronic changes being linked to various diseases, including type 2 diabetes, hypertension, cardiovascular diseases, depression, and autoimmune conditions (Ganzel et al. 2010; McEwen and Seeman 1999).

The metabolic system is involved in distributing energy resources throughout the body. These energy resources include glucose and blood lipids such as cholesterol and triglycerides. Generally, different types of cholesterol are distinguished, the main types being low-density (LDL) lipoproteins and high-density (HDL) lipoproteins, with total cholesterol as a measure reflecting the total amount of lipids circulating in the blood stream. While HDL is considered to promote health and to protect against atherosclerosis, high levels of triglycerides might be a risk factor for disease. Additionally, LDL and total cholesterol are associated with cardiovascular ill health. Triglycerides are another commonly investigated blood lipid, reflecting fat deposits, with higher values associated with diabetes and obesity. In addition to blood lipids, measures of glucose are also included among metabolic indicators. Glycosylated hemoglobin (HbA1c) is an integrated measure reflecting an individual's glucose metabolism during the previous 30–90 days and that has been linked to diabetes.

Recent research underscores the importance of immune system functioning and inflammatory mechanisms underlying various diseases, including cardiovascular disease (Kiecolt-Glaser 2009; Glaser and Kiecolt-Glaser 2005). The immune system plays a central role as a barrier, active in defending and protecting the body from infections and other threats. There are a number of immune system markers, including several different cytokines, which have their specific functions in the complex process of protecting the body. These processes are further complicated by the fact that acute and long-term responses of the immune system involve diverse parts of the immune system.

In addition to investigating separate physiological systems and focusing on physiological indicators reflecting activity within a specific system, the concept of allostatic load has been proposed as a complementary approach that underscores the mutual interactions between different bodily systems by describing how physiological functioning within theses bodily systems relates to health and disease (e.g., McEwen

2007; McEwen and Seeman 1999). The allostatic load model also takes into account the ability of bodily systems to reach stability through change and distinguishes between the effects of acute and chronic responses. While acute responses that are necessary to adapt to current challenges and demands have a protective effect when they are followed by periods of rest and recovery, prolonged activation of different bodily systems increases the wear and tear of bodily resources. Partly, such wear and tear is related to natural life course changes and the reduced flexibility of aging bodily systems. Young and healthy functioning bodily systems respond with activity within a given and optimal range. However, daily wear and tear may, over time, result in physiological dysregulation. Dysregulation in multiple bodily systems, characterized by activity deviating from the optimal range or by increased difficulties in returning to baseline levels (or resting levels) after various bodily challenges, may result in allostatic load. Such cumulative dysregulation may result in an allostatic load that, in turn, increases the risk for future ill health and disease and reduces the chances for long-term physical health. To reflect the multisystems approach, allostatic load has been operationalized as a summary indicator of physiological challenge across multiple bodily systems (McEwen and Seeman 1999). Typically, a measure of allostatic load includes one or several physiological indicators of cardiovascular, endocrine, immune, and metabolic system functioning. To date, research has shown that high allostatic load is associated with different health-related outcomes, including cardiovascular disease, cognitive decline, and mortality (Ganzel et al. 2010).

Different Aspects of Mental Well-Being

Based on how mental well-being is defined, the research within the field can be divided into two broad orientations (Deci and Ryan 2008; Ryan and Deci 2001). Each of these orientations focuses on different, yet overlapping, aspects of well-being, namely, hedonic aspects of well-being and eudaimonic aspects of well-being (Kashdan et al. 2009; Keyes et al. 2002). While the hedonic orientation focuses on subjective well-being, the eudaimonic orientation underscores the pursuit of growth, human fulfillment, and psychological well-being. The differences between the two orientations become clear when looking at how these different aspects of mental well-being are defined and assessed (e.g., Ryan and Deci 2001). Subjective well-being is commonly associated with happiness. The assessment of subjective well-being includes measures of positive affect, affect balance, happiness, and life satisfaction (Diener 1984; Ryan and Deci 2001). In contrast, psychological well-being refers to a broader conceptualization, including characteristics of the optimally functioning individual. Over the past several decades, psychological well-being has mainly been measured using the six well-being dimensions included in the Ryff scales (Ryff 1989; Ryff and Keyes 1995). However, other ways of measuring psychological well-being cover individual strengths relating to meaningfulness, such as sense of coherence (Antonovsky 1985, 1987). Theoretical reviews (Deci and Ryan 2008; Kashdan et al. 2009; Ryan and Deci 2001) comparing the philosophical underpinnings, measures, and empirical findings of the two orientations conclude that in investigating different aspects of mental well-being using different yet slightly overlapping self-report measures, the two lines of research complement each other. This complementary perspective is supported by empirical studies of mental well-being profiles, including measures of both subjective and psychological well-being (Keyes et al. 2002).

Hedonic Well-Being and Its Physiological Correlates

Most of the existing research on physiological correlates of mental well-being has focused on the hedonic aspects of well-being in terms of positive affect and positive emotions (for detailed reviews, see Pressman and Cohen 2005; Steptoe et al. 2009). In contrast, the research investigating physiological correlates of more complex aspects of hedonic well-being, such as life satisfaction and subjective well-being which go beyond pure ratings of emotions or affect, is scarce. In part, this results from psychology's primary concern with emotion and affect. However, with regard to the linkages to various health-related outcomes, emotion and affect have been suggested to explain how psychosocial stress can influence physical health (Pressman and Cohen 2005).

Research on central physiological correlates (i.e., brain functioning) of positive affect draws on findings showing that there is a differentiation between positive and negative emotional processes in the brain. The prefrontal cortex has been identified as a part of the brain that is involved in emotional processes, and so this part of the brain appears to be particularly important for mental well-being (Davidson 2004). Studies on mental well-being have also focused on such measures as those used in earlier findings relating to asymmetric activity between the left and right hemispheres. As regards levels of activity in the brain, a study focusing on mental well-being has shown that greater left than right activation of the prefrontal cortex is associated with higher levels of positive affect. However, activation of the left and right frontal hemispheres was shown to not be associated with positive affect (Urry et al. 2004).

As regards cardiovascular indicators, systematic reviews show that positive affect and positive emotions are related to increases in cardiovascular responses (Pressman and Cohen 2005). These relationships have been found both in experimental and correlational studies. However, increases in blood pressure have been established in both experimental and correlational research, while increases in heart rate have been found in experimental studies only. When it comes to the size of the increase, the magnitude is typically relatively small. A related line of research investigating the form and function of positive emotions has shown that the experience of positive emotions, by restoring autonomic activity to midrange levels, decreases the duration of cardiovascular arousal and thus facilitates physiological recovery, which, in turn, may hinder detrimental processes and promote health (Fredrickson 1998, 2004; Fredrickson et al. 2000). However, other experimental studies have failed to replicate these findings (Steptoe et al. 2005).

For endocrine measures, including cortisol and catecholamines (adrenaline and noradrenaline), experimental research inducing positive affect by active techniques, including study participants' experiences, results in increased cortisol levels (Pressman and Cohen 2005). Yet, laboratory studies inducing positive affect by passive techniques (showing film clips, listening to music, or similar) show no consistent cortisol increases but rather a decrease or no change at all. In contrast, research in real-life settings typically shows that positive affect is associated with lower cortisol levels. However, these results tend to be stronger for trait positive affect than for state positive affect. As regards catecholamines, positive affect (trait and state) has been coupled with lower levels of both adrenaline and noradrenaline in studies conducted in real-life settings; however, some studies have shown null findings. For laboratory studies, the findings on catecholamines are mixed, with some studies showing positive affect as being associated with higher noradrenaline levels or both higher levels of adrenaline and noradrenaline, while other studies show null findings. As for cortisol, the mixed laboratory findings can be explained by differences in inducing positive affect, with active techniques being associated with a clear increase, while results for passive techniques are less clear (Pressman and Cohen 2005; Steptoe et al. 2009). It is important to bear the differences in mind for individuals who are reacting emotionally to active and passive experimental techniques, as well as the potential differences between state and trait positive affect, when transferring the research findings between settings and when evaluating the associations between positive affect and health outcomes.

There are several potential indicators of immune system functioning (Kiecolt-Glaser 2009). Cytokines constitute a larger group of immune system markers that have been found to be helpful in measuring physical health. The existing laboratory studies suggest that induced positive affect is linked to changes in immune system response. So far, only a few field studies have included immune system indicators, but these studies suggest that both trait and state positive affect are related to higher secretory immunoglobulin A (SIgA) levels (Pressman and Cohen 2005; Steptoe et al. 2009).

To conclude, an increasing number of studies that have investigated the physiological correlates of positive affect and positive emotions have shown that positive affect is linked to physiology. Importantly, the relationships between positive affect and emotions recur across different physiological systems, including both central and peripheral physiological indicators, such as brain activity and cardiovascular, endocrine, and immune system markers. Although additional research is needed to clarify patterns of physiological correlates and to delineate how these patterns relate to health over time, the findings clearly show that there are physiological correlates of mental well-being in terms of positive affect and positive emotions that are central to physical health.

Eudaimonic Well-Being and Its Physiological Correlates

Eudaimonic well-being includes meaning, purpose, and actualization of individual potential. In contrast to measures of hedonic aspects of mental well-being, the eudaimonic aspects of mental well-being encompass a range of different concepts and related measures. These measures often cover dimensions such as meaningfulness, purpose, and belongingness (e.g., Ryan and Deci 2001; Ryff and Singer 1998). Although there are several different operationalizations of eudaimonic well-being (Kashdan et al. 2009), sense of coherence (Antonovsky 1985, 1987) and Ryff's psychological well-being scales (Ryff 1989; Ryff and Keyes 1995) stand out as the conceptualizations that offer the most solid frameworks for the empirical investigation of linkages to physiological indicators and physical health.

Sense of Coherence and Its Physiological Correlates

Sense of coherence (SOC) refers to the level of stability in an individual's confidence in structure, predictability, and intelligibility (Antonovsky 1985, 1987). These three dimensions are considered to characterize resilient individuals who manage to deal successfully with life, find meaning, and grow by facing adversity. This means that SOC can be considered a global orientation that influences the individual's perception and interpretation of various situations. As a global orientation, SOC involves taking into consideration whether everyday life is demanding and challenging, whether these demands and challenges need to be dealt with, and whether there are resources available for dealing with these challenges and demands. In keeping with Antonovsky (1985, 1987, 1993), an individual's SOC may modify a stress reaction in various ways at various stages of the stress reaction. For example, individuals with a stronger SOC are less likely to experience stimuli as stressful and consequently do not suffer from the stress and strain that burden individuals with a weaker SOC. Thus, the constant ongoing and lifelong interplay between SOC and stress is assumed to influence physical health. While it is known that SOC is associated with various health outcomes (Surtees et al. 2002), less is known about the actual physiological correlates of SOC that underlie these associations.

Physiological Correlates of Sense of Coherence

Much of the research on physiological underpinnings of SOC is cross-sectional and has compared physiological correlates in individuals with distinct profiles of SOC. When it comes to cardiovascular indicators, middle-aged women with a weak SOC have been found to have higher systolic blood pressure than women with a strong SOC; diastolic blood pressure follows the same pattern, albeit not statistically significantly (Lindfors et al. 2005). Yet another study (Konttinen et al. 2008) which included a larger sample of women and men showed no associations between SOC and blood pressure. As for metabolic markers such as blood lipids, middle-aged women with a weak SOC have been shown to exhibit poorer lipid profiles in terms of lower levels of high-density lipoproteins (HDLs) and higher levels of triglycerides than do women with a strong SOC (Svartvik et al. 2000). Another study failed to replicate theses results for HDL and triglycerides, mainly due to a lack of statistical power (Lindfors et al. 2005). However, in showing that women with a weak SOC had higher levels of total cholesterol than women with a strong SOC, the association between blood lipids and SOC was replicated. Yet, a recent study that included analyses of SOC and total cholesterol in women and men showed no differences in the associations between total cholesterol and SOC for subgroups with distinct SOC profiles (Konttinen et al. 2008).

The associations of cumulative load, in terms of allostatic load and SOC, have also been investigated longitudinally in women (Lindfors et al. 2006). The findings have shown that allostatic load in terms of cardiovascular, metabolic, and lung function was a significant predictor of SOC in middle-aged women with no previous diagnosis of pathology. Interestingly, analyses of the different components included in SOC (i.e., manageability, meaningfulness, and comprehensibility) revealed significant associations between allostatic load and the meaningfulness component, but not for the manageability component. These findings suggest that the relationships between cumulative physiological load not only result from the fact that control, in terms of manageability, is associated with physiology but also underscore the importance of meaningfulness (Lindfors et al. 2006).

Looking across the research on physiological correlates of SOC, it becomes clear that research has focused on peripheral physiological correlates and that studies of central physiological correlates are lacking. Moreover, the existing findings relating to peripheral correlates are mixed. Cohort studies that include only women suggest an association between both cardiovascular and metabolic indicators and SOC (Lindfors et al. 2005). More specifically, the preliminary findings on women show that a stronger SOC is associated with a more favorable physiological profile, while a weaker SOC is associated with a less favorable but also a more exhaustive, physiological profile. In contrast, a recent large-scale study that included adult women and men showed no associations between physiological indicators and SOC (Konttinen et al. 2008). As regards the physiological correlates of SOC, additional research is needed to clarify whether the relationships between physiological indicators and SOC hold for women only and whether these associations are restricted to cardiovascular and metabolic indicators or also include endocrine and immune system parameters. The mixed findings may also result from methodological differences between studies. Among these are different measures of SOC and, as a result, different cutoff points for distinguishing individuals with a strong and a weak SOC, respectively. But current empirical evidence allows for no firm conclusions as regards the physiological correlates of SOC.

Psychological Well-Being

The lifespan developmental approach to mental well-being formulated by Ryff (1989; Ryff and Keyes 1995) describes psychological well-being in terms of six dimensions, including autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance. These dimensions are considered to characterize well-functioning individuals who manage to deal successfully with daily life, find meaning, and grow from experiences. Importantly, psychological well-being profiles across the different dimensions have been found to vary with respect to age, which underscores natural but dynamic changes in psychological well-being over a lifetime. In keeping with this perspective on psychological well-being, eudaimonic aspects of mental well-being are assumed to be linked to health (Ryff and Singer 1998). This reasoning is based on a view of a good life being associated with a health-promoting lifestyle and behaviors but also with physiological processes linked to the six dimensions of psychological well-being. This means that high levels of growth, mastery, meaning, positive relations, and so on, are important for maintaining physical health and increased resilience.

Physiological Correlates of Psychological Well-Being

Research on physiological correlates of psychological well-being, in terms of the Ryff scales, has been mainly correlational and has examined how the different dimensions of psychological well-being, along with a measure that includes all of the dimensions of well-being, are related to different physiological indicators.

In respect to central mechanisms that focus on how brain activity relates to psychological well-being, greater left than right activation of the prefrontal cortex has been associated with higher levels of psychological well-being, including total scores and five of the dimensions included in Ryff's well-being scales (i.e., environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance). Associations have also been found between activation of the left prefrontal cortex and total scores of psychological well-being, as well as for all of the separate dimensions of psychological well-being, excluding autonomy. Importantly, these associations with psychological well-being remain stable when the effects of positive affect are statistically removed. Although the relationships between central physiological indicators and psychological well-being were small, the associations were robust, which indicates that psychological well-being is linked to individual behavioral engagement. There were, however, no linkages between right hemisphere activation and psychological well-being, which supports previous research that showed that the left hemisphere is more involved in processes involving positive affect (Urry et al. 2004).

When it comes to cardiovascular indicators, the findings have shown no associations between blood pressure and the different dimensions of well-being included in the Ryff scales (Lindfors and Lundberg 2002; Ryff et al. 2006). This holds for blood pressure assessments from both health checkups and measurements taken in settings of daily life (Lindfors and Lundberg 2002).

As for endocrine markers such as catecholamines and cortisol, findings suggest that some of the well-being dimensions are associated with endocrine functioning. Regarding catecholamines, Ryff and colleagues (2006) studied older women and found that adrenaline and noradrenaline, respectively, were associated with one of the six dimensions of psychological well-being included in the Ryff scales. In particular, adrenaline was associated with higher levels of positive relations, while noradrenaline was associated with higher levels of autonomy. In contrast, a study including a smaller group of middle-aged women and men found no relationships between catecholamines and psychological well-being (Lindfors and Lundberg 2002). However, this study did show that cortisol was associated with psychological well-being: individuals with high levels of psychological well-being had lower levels of cortisol output throughout the day than did individuals with low levels of psychological well-being. These differences were particularly pronounced for morning cortisol. Looking at the different dimensions of psychological well-being, high cortisol levels in the morning were associated with lower levels of environmental mastery and self-acceptance. Moreover, high levels of cortisol throughout the day were associated with low environmental mastery and purpose in life. In part, these findings have been replicated by Ryff and colleagues (2006) who found that cortisol was associated with high personal growth and purpose in life. Again, higher scores on these two dimensions of psychological well-being were associated with lower levels of cortisol throughout the day, including morning cortisol levels. However, no associations were found for any of the other four dimensions of well-being.

Research focusing on metabolic indicators, including blood lipids and HbA1c, has shown that higher levels of HDL are associated with personal growth and purpose in life, while a high total cholesterol/HDL ratio is associated with lower personal growth (Ryff et al. 2004, 2006). However, other studies report no associations between blood lipids (HDL, LDL, total cholesterol, and triglycerides) and psychological well-being (Lindfors and Lundberg 2002). As for HbA1c, no associations with psychological well-being have been found (Tsenkova et al. 2007).

Focusing on associations between immune system markers and psychological well-being, one study has shown that psychological well-being was associated with a strong vaccine-induced cytokine production (Hayney et al. 2003). Another study on cytokines, albeit a different type of cytokines, found associations with some of the well-being dimensions. Specifically, and in line with the study's hypothesis, higher levels of positive relations with others and with purpose in life were associated with cytokines. Importantly, these relationships remained after statistically controlling for potential confounding variables, such as depression (Friedman et al. 2007).

As regards the multisystems approach of allostatic load, one study has explored the associations between allostatic load and positive relations with others. The research findings of this study revealed that positive relations with others were associated with a lower allostatic load and with less dysregulation within bodily systems (Seeman et al. 2002).

To summarize, the findings on physiological correlates of psychological well-being, in terms of the Ryff scales, are preliminary and show mixed results for different physiological systems and their respective indicators. The findings are promising for central indicators and allostatic load, but since only a few studies on these indicators have been carried out, more research is needed to assess the validity of these findings. In regard to cardiovascular indicators, preliminary findings suggest no associations, and additional research on more diversified groups is needed to clarify any potential associations with metabolic markers. Also, the findings relating to catecholamines are mixed. However, the preliminary research on cortisol and immune system markers suggests a link to psychological well-being. As for the immune system, research has focused on different indicators, and these findings need to be replicated in other groups in order to assess their validity. When it comes to cortisol, individuals with high psychological well-being have cortisol levels within an optimal or moderate range which suggests that the cortisol output is more moderate. Although the findings differ between studies with regard to the dimensions of psychological well-being having an association with cortisol, lower cortisol levels have been linked with purpose in life. This, in turn, suggests that lower cortisol levels and purpose in life may be crucial to maintaining health.

Integrating Findings on Physiological Correlates of Mental Well-Being

Looking across the research on physiological correlates of mental well-being makes it clear that most studies relate to the hedonic orientation and investigate associations between positive affect and different physiological indicators. The recent systematic reviews of positive affect and physical health and potential physiological correlates (e.g., Steptoe et al. 2009; Pressman and Cohen 2005) illustrate clearly that positive emotions and affect are associated with physiology. The fact that there are systematic reviews also suggest that it should be both possible and useful to procure summaries of current findings, in order to consolidate and refine the research with respect to different research designs and their relation to different physiological indicators (in terms of acute and chronic physiological functioning). In addition, the research often includes and controls for spurious relationships of other factors, including psychosocial and demographic factors such as age, gender, social status, and ethnicity (Pressman and Cohen 2005). In contrast to the research on affect and emotions, the knowledge of physiological correlates of other hedonic measures (e.g., life satisfaction) is very limited. However, some studies, including the parallel investigation of hedonic and eudaimonic well-being, have explored life satisfaction (e.g., Urry et al. 2004). Although the existing findings suggest that more complex measures of hedonic well-being have different physiological correlates than do eudaimonic measures of well-being and positive affect, the findings are still preliminary and do not cover different physiological systems.

While the research on hedonic measures that focus on positive emotions and affect clearly show an association with physiology, the existing research on physiological correlates of eudaimonic measures is, at best, promising. Specifically, the studies on eudaimonic measures, such as sense of coherence and psychological well-being, suggest an association between physiological functioning and meaning (e.g., Lindfors and Lundberg 2002; Lindfors et al. 2006; Ryff et al. 2006). Such associations between experiences of meaning and physiology also point to potential linkages between positive psychological functioning, physiology, and increased improvement of long-term health. In addition, the findings underscore one of the central aspects of the eudaimonic orientation, namely, the aspect of leading a meaningful life (Ryff and Singer 1998). However, the preliminary findings on eudaimonic well-being should not be regarded as conflicting with findings on hedonic well-being. Instead, research including the parallel investigation of hedonic and eudaimonic measures of well-being with the same study participants and in the same setting suggests that the physiological correlates of hedonic and eudaimonic well-being, respectively, are distinct, yet somewhat overlapping (e.g., Ryff et al 2006; Urry et al. 2004). This, in turn, suggests that there are physiological correlates of both hedonic and eudaimonic well-being but that these have different roles. Following Fredrickson's (1998, 2004) line of reasoning, experiences of hedonic well-being in terms of positive affect and positive emotions, and their broadening of thought-action repertoires, are necessary for an individual to build and achieve eudaimonic well-being, including a meaningful life. This view suggests that there is a constant interplay between hedonic and eudaimonic aspects of well-being. Such interplay between different levels of mental well-being could partly explain variations in physiological correlates. However, at the same time, such associations also underscore the need to distinguish between acute and chronic physiological functioning and their associations with hedonic and eudaimonic well-being, respectively. Ideally, further research into the physiological correlates of mental well-being should include repeated assessment of physiological indicators across different bodily systems in a laboratory setting and in real-life situations among women and men taking part in a longitudinal study. This would allow for the disentanglement of acute and chronic physiological patterns and for the investigation of single physiological indicators and cumulative physiological functioning in terms of allostatic load (as related to hedonic and eudaimonic well-being). However, it is not always possible to bring about certain research designs, and since many groups are not included in longitudinal research programs, additional cross-sectional laboratory and real-life studies are needed in order to look at fine-grained patterns in different groups, including, for instance, children and adolescents. In studying physiological correlates of mental well-being in different groups, it is important to make expectations clear in terms of physiology in healthy individuals without chronic disease or other major health problems. Importantly, the flexibility of bodily systems varies according to health status but also with age (e.g., McEwen and Seeman 1999). When it comes to optimal physiological functioning, healthy and younger individuals more often exhibit ideal physiological patterns with moderate levels of activity, adequate recovery, and so on, than do older individuals with chronic disease. This means that it can be difficult to distinguish physiological correlates of mental well-being in groups, including younger and/or older individuals. Specifically, trends may not become statistically significant. Or, perhaps other, nontraditional statistical methods are needed to adequately measure physiological correlates of healthy individuals. In contrast, the bodily systems of older or sick individuals have started to wear down, meaning that these individuals typically have higher levels of allostatic load than do other individuals. Therefore, it is easier to distinguish unfavorable patterns of bodily functioning and link these to mental well-being. Yet, in addition to physiological functioning, patterns of mental well-being also seem to vary by age and health status. However, such associations underscore the need to investigate additional and alternative ways of explaining the physiological patterns related to hedonic and eudaimonic measures of mental well-being.

Although the research suggests that there is a direct pathway between physiology and mental well-being (e.g., Dockray and Steptoe 2010), other factors may also affect this relationship, such as the influence of more favorable lifestyle choices and health behavior patterns, genetics, early childhood development, and psychosocial factors including social status and resources available for dealing with daily stress and strain. It is vital that future research explores the impact of such factors on variations in mental well-being and physiology across the course of life.

Conclusions

This chapter has summarized research findings on commonly studied central and peripheral bodily systems and their relations with hedonic and eudaimonic aspects of mental well-being. While findings show clear associations between different physiological systems and hedonic well-being in terms of positive affect, findings related to eudaimonic well-being are inconclusive but seem to suggest that there are physiological correlates of meaning. However, additional research is needed to further clarify how physiological underpinnings of various aspects of mental well-being vary in different groups of individuals across the course of life. To make such clarification possible, future research designs need to encourage the parallel study of bodily functioning associated with hedonic and eudaimonic well-being while taking into account health behaviors and psychosocial factors. Ultimately, findings linking mental well-being and physiological functioning may help tailor interventions that can promote and build positive health.

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