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Research report

Clues to maintaining calorie restriction? Psychosocial profiles of successful long-term restrictors ☆

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ABSTRACT

To combat the obesity epidemic, interventions and treatments often recommend low-calorie dieting. Calorie restriction (CR) as a weight intervention, however, is often unsuccessful, as most people cannot sustain the behavior. Yet one small group has maintained extreme CR over years – members of the CR Society and followers of The CR Way. This study examined stable psychosocial characteristics of these individuals to identify traits that may promote success at long-term CR. In 65 participants, we measured diet, eating behaviors, and personality traits comparing calorie restrictors with two age-, gender-, ethnicity-, and education-matched comparison groups (normal weight and overweight/obese). We first tested whether the CR group restricted calories without indications of eating disorder pathology, and second, what crystallized psychosocial characteristics set them apart from their nonrestricting comparisons. Results indicated the CR group averaged 10 years of CR but scored lower than comparison groups on measures of disordered eating ($p < .001$) and psychopathology ($p < .001$). Particularly against overweight/obese participants, CR participants scored lower on neuroticism ($p < .04$) and hostility ($p < .01$), and were stronger in future time orientation ($p < .05$). Overall, CR profiles reflected high self-control and well being, except for having few close relationships. This study suggests a potential predisposition for successful long-term CR without disordered eating. Since modifying trait factors may be unrealistic, there may be psychosocial boundaries to the capacity for sustaining CR. Paralleling a movement toward personalized medicine, this study points toward a personalized *behavioral* medicine model in behavioral nutrition and treatment of overweight/obesity.

Introduction

Overweight and obesity are highly prevalent in the United States (Flegal, Carroll, Kit, & Ogden, 2012), yet weight-loss is an elusive goal and dieting an often ineffective solution. While dieting – defined here as calorie restriction (CR) – does result in initial weight-loss and is a common clinical recommendation for weight-loss (van Dillen, van Binsbergen, Koelen, & Hiddink, 2013), randomized controlled trials of dieting demonstrate average *maintained* weight-loss below 1 kg (2.1 lbs; Tomiyama, Ahlstrom, & Mann, 2013). The real challenge then is maintenance; indeed, dieting research has found that the average man could sustain CR for only 6 weeks and the average woman only 4 weeks (Williamson, Serdula, Anda, Levy, & Byers, 1992). CR adherence has been demonstrated to be strongest in the initial weeks with nonadherence rising in subsequent months (Jeffery et al., 2000), and even staff-supported interventions receive only 25% attendance at treatment sessions after 12 months (Jeffery, Wing, Thorson, & Burton, 1993). This highlights the paradox of dieting: for optimal weight-loss, dieting should continue indefinitely, but dieting failure increases over time. Accordingly, CR maintenance failure has been identified as the strongest basis for modest weight-loss outcomes (Heymsfield et al., 2007). Perhaps then, sustained weight-loss is unobtainable largely because CR is unsustainable.

To understand why CR might be unsustainable for many who are seeking weight-loss, a critical step is identifying individual differ-

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ences underlying successful long-term restriction. Although dieting failure is the norm and long-term successes are uncommon, fortunately, there is a small cohort successfully adhering to CR for years to even decades – the Calorie Restriction (CR) Society and followers of The CR Way. Since long-term CR is their hallmark, identifying distinguishing behavioral and psychosocial characteristics of these individuals may help predict which individuals might be successful at CR and when CR might be a recommendable weight-loss intervention.

Of similar attempts to understand dieting success, most notable is the National Weight Control Registry, which studies individuals with self-reported weight-loss of at least 30 pounds and maintenance of at least 1 year. The Registry averages 6.2 years of weight-loss maintenance and has provided valuable information about common practices of weight-loss maintenance such as daily weighing and exercising (Thomas, Bond, Phelan, Hill, & Wing, 2014). Building on these findings, our study sought to answer an upstream question: what type of individuals can maintain calorie-restricted diets over the long-term, and how are these people unique? For comparison, we recruited free-eating non-CR individuals to more clearly understand the distinguishing characteristics of successful long-term restrictors. Furthermore, we sharpened our inclusion criteria to at least 2 years of CR (whenever possible obtaining third-party confirmation), resulting in a CR group that, upon enrollment, already averaged 10 years of CR. Before conducting any comparisons, we verified the CR group's self-report behavior, using objective measures such as fasting glucose levels to confirm that they were indeed restricting calories.

Our first aim was to determine whether the CR group differed from non-CR comparisons in disordered eating symptomatology to ensure that any observed differences would be attributable to a unique ability to maintain long-term CR rather than psychopathological traits common to anorexia nervosa. We therefore tested for common symptoms of eating disorders such as excessive shape and weight concern (Gowers & Shore, 2001) and psychopathology like depressive symptomology (Ackard, Croll, & Kearney-Cooke, 2002; Cachelin & Regan, 2006; Crow, Eisenberg, Story, & Neumark-Sztainer, 2006; Gillen, Markey, & Markey, 2012) and obsessive compulsive tendencies (Rothenberg, 1986). We also tested differences in behavioral eating patterns such as external food cue sensitivity, emotional eating, and restraint.

Our second aim was to test our hypothesis that, considering dieting failure is the norm, the CR group must possess key personality characteristics or self-regulation abilities, unrelated to eating (more specific to behavior in general rather than uniquely about eating), predisposing them to successful CR. In the context of this cross-sectional design, we focused on relatively stable characteristics in a preliminary attempt to grasp the directionality of correlational findings. Low neuroticism and high conscientiousness have been identified as influential in successful short-term dieting (Heaven, Mulligan, Merrilees, Woods, & Fairooz, 2001). Therefore, we expected the CR group would score lower on neuroticism and higher on conscientiousness than free-eaters. Since compulsive eating, versus controlled eating, is associated with hostility (Kagan & Squires, 1984; van den Bree, Przybeck, & Cloninger, 2006), we also hypothesized that the CR group would demonstrate lower hostility, congruent with their considerable control over eating. CR maintenance also requires delay of gratification (Epstein, Salvy, Carr, Dearing, & Bickel, 2010), and similarly, future time orientations are positively associated with weight management behaviors and negatively associated with obesity (Guthrie, Butler, Lessl, Ochi, & Ward, 2013). Therefore, we predicted that the CR group would show stronger future-oriented and weaker present-focused time perspectives.

Finally, as our calorie restrictors varied widely in the length of time they had practiced CR, our third aim was to determine whether positive characteristics were strongest in those who practiced the longest. This would lead us to infer that the traits may facilitate the maintenance of CR. Thus, there might be a relationship between duration of CR practice and both key psychosocial characteristics and markers of CR behavior. In this vein, we tested for associations between years of CR, calorie consumption, and the above-mentioned stable psychosocial characteristics. We ultimately aimed to determine, at least preliminarily, if these qualities would be related to the ability to better maintain CR over time, although in a cross-sectional manner.

Materials and methods

Subjects

We recruited 30 individuals from the CR Society and followers of The CR Way. We chose this population as they are the largest organization of calorie restrictors with detailed documentation of restriction history. This group also explicitly prioritizes optimal nutrition, which mitigated concerns about malnutrition. Inclusion criteria for the CR group were reporting (1) Body Mass Index (BMI; weight [kg]/height^2 [m]) 24.99 or below and (2) over 2 years of CR. Whenever possible, the President of The CR Way Longevity Center and Vice President for Research of the CR Society International and the Chairman of the Board of the CR Society International and Treasurer and Vice President of The CR Way Longevity Center verified each participant's self-reported duration of CR.

We also recruited two matched comparison groups: (a) normal weight (BMI 18.5–24.99) free-eaters ($n = 16$) and (b) overweight/obese (BMI 25+) free-eaters ($n = 25$) to ensure that the comparisons represented a broad BMI range. Six of these comparisons were siblings of CR participants. We matched the comparison groups on age, gender, ethnicity, and educational attainment. All participants were nonsmokers and none was pregnant. We recruited the CR group in collaboration with the CR Society and The CR Way and then recruited comparison groups from the surrounding community targeting demographics matching CR participants.

Procedure

The University of California, San Francisco (UCSF) Committee on Human Research approved all procedures. Participants completed measures assessing psychosocial characteristics and structured interviews assessing social interactions. A subset ($n = 26$) of local participants ($n = 38$) completed the surveys as outpatients, while all others traveled to the UCSF Clinical and Translational Science Institute Clinical Research Center (CCRC) to participate as inpatients. To minimize confounds from jetlag and unfamiliar settings, participants located over 100 miles away spent an acclimation night at CCRC before completing procedures. To minimize diurnal activity pattern confounds, participants woke up, ate, and slept according to usual schedules. The CCRC metabolic kitchen prepared specialized calorie-restricted meals for CR participants.

All participants also completed food diaries designed by a registered dietitian that reflected all foods and liquids consumed and the time of day consumed on the Sunday, Monday, and Tuesday preceding the CCRC visit to capture weekend/weekday variability. In addition, each participant received a Bayer glucometer and video/phone training for use during the 4 weeks preceding the CCRC visit. On four randomly chosen nights, study staff contacted participants between 17:00 and 20:00 and told them to note time of last meal and then fast from midnight onward. Participants then reported their fasting blood glucose upon awakening.

Measures

Demographic measures

Ethnicity. Participants self-reported their ethnicity as White, Black/African American, Hispanic/Latino, American Indian/Alaska Native, Asian/Pacific Islander, or Other.

Education. Participants reported the highest level of education they had completed: High School/GED, Some College, Associate's Degree, Bachelor's Degree, Master's Degree, Professional/Doctoral Degree.

Income. Although we matched the groups on education, we measured income because it is only moderately correlated with education (Krieger, Williams, & Moss, 2003). Participants selected an income category reflecting their total pretax household income from the previous 12 months: 1 = $0–$10,000; 2 = $11,000–$20,000; 3 = $21,000–$35,000; 4 = $36,000–$50,000; 5 = $51,000–$75,000; 6 = $76,000–$100,000; 7 = $100,000+.

General intelligence. The Wonderlic Personnel Test (Dodrill, 1981), a 12-minute, 50-item test, measured intelligence, with higher scores reflecting greater general intelligence. Although briefer, Wonderlic scores highly correlate with other established measures of IQ such as the Weschler Adult Intelligence Scale (Dodrill & Warner, 1988). The general population average Wonderlic score is 20 (Blackwell, 2001).

Psychological measures

Depression. The Center for Epidemiologic Studies Depression Scale (CES-D) measured depressive symptomatology (Radloff, 1977). This is a 20-item measure assessing depressed mood, feelings of guilt, worthlessness, helplessness and hopelessness, psychomotor retardation, loss of appetite, and sleep disturbance. The CES-D indicates a cutoff score of 16 or greater to identify those at risk for clinical depression, which has high internal consistency and sensitivity (Lewinson, Seeley, Roberts, & Allen, 1997). The Cronbach's alpha reliability in our sample was $\alpha = .82$.

Eating behavior. The Dutch Eating Behavior Questionnaire (DEBQ; van Strien, Frijters, Bergers, & Defares, 1986) assessed retrained, emotional, and external eating. This measure has high validity and internal consistency, and high stability for each subscale (van Strien, Frijters, Bergers, & Defares, 1986). The Cronbach's alpha reliability in our sample was $\alpha = .87$ for restrained eating, $\alpha = .95$ for emotional eating, and $\alpha = .78$ for external eating.

Eating disorder pathology. The Eating Disorder Examination-Questionnaire (EDE-Q: Fairburn & Beglin, 1994) measures eating disorder pathology symptoms such as restraint and eating, shape, and weight concern. This self-report version of the Eating Disorder Examination (Fairburn & Cooper, 1993) has demonstrated high internal consistency and test–retest reliability (Luce & Crowther, 1999). The Cronbach's alpha reliability in our sample was $\alpha = .83$ for restraint, $\alpha = .76$ for eating concern, $\alpha = .91$ for shape concern, and $\alpha = .84$ for weight concern. Scores above 4 on items 12, 13, and 22 are indicative of eating disorder pathology (Fairburn & Beglin, 1994).

Obsessive compulsive behavior. The Maudsley Obsessive Compulsive Inventory (MOCI; Hodgson & Rachman, 1977) assesses obsessive-compulsive behavior using a 30-item true–false scale. This measure has demonstrated good validity and test–retest reliability (Hodgson & Rachman, 1977). The Cronbach's alpha reliability in our sample was $\alpha = .80$.

Personality. The Big Five Inventory (John, Donahue, & Kentle, 1991) measures personality traits of openness, neuroticism, conscientiousness, extraversion, and agreeableness. This is the most common measure of personality (John & Srivastava, 1999; McCrae & Costa, 1999). The Cronbach's alpha reliability in our sample was $\alpha = .84$ for openness, $\alpha = .83$ for neuroticism, $\alpha = .79$ for conscientiousness, $\alpha = .80$ for extraversion, and $\alpha = .83$ for agreeableness. The Cook–Medley Hostility Scale (Barefoot, Dodge, Peterson, Dahlstrom, & Williams, 1989) a 50-item subscale of the Minnesota Multiphasic Personality Inventory (Shipman, 1965), measured hostility. Scores range from 0 to 50, with higher scores indicating greater hostility. The Cronbach's alpha reliability in our sample was $\alpha = .89$.

Time perspective. The Zimbardo Time Perspective Inventory (Zimbardo & Boyd, 1999) characterizes stable orientations toward past-negative, past-positive, present-fatalistic, present-hedonistic, and future time perspectives. The past-negative time type focuses on distressing past experiences. The past-positive type views the past nostalgically. The present-hedonistic type shows predominantly pleasure-seeking motivation and is associated with less healthy lifestyles and greater risk-taking. The present-fatalistic type feels anxious and powerless about the future. The future-focused type demonstrates high ambition and goal-orientation, which can weaken social relationships (Zimbardo & Boyd, 1999). The Cronbach's alpha reliability in our sample was $\alpha = .80$ for past-negative perspective, $\alpha = .79$ for past-positive perspective, $\alpha = .73$ for present-fatalistic perspective, $\alpha = .79$ for present-hedonic perspective, and $\alpha = .73$ for future perspective.

Social relationships. Trained study staff conducted a structured interview to asses each participant's close relationships and hobbies. The questions asked were, "Who are the people you spend the most time with?" and "What are hobbies you enjoy?" Trained staff coded responses for the number of close relations listed, as well as if they were friends, family, or coworkers. They also coded for self-descriptive language like "loner" and "solitary," and the number of social hobbies that involved interacting with others (e.g., team sports). Trained staff coded independently; in the case of discrepancies, the first and last author agreed upon the best answer.

Metabolic and nutritional measures

BMI. Nursing staff measured body weight using a Scaletronix scale (White Plains, NY) and height from duplicate measures from a wall-mounted stadiometer. A platform-based bioelectric impedance Tanita Professional Body Composition Monitor SC-331S (Arlington Heights, Illinois) confirmed weight. We used these measures to calculate BMI.

Kilocalorie intake. Research staff used FoodPro software (Aurora Information Systems, Cherry Hill, NJ) to calculate kilocalorie intake for each food diary day, and we averaged these values over the 3 days.

Fasting blood glucose. Fasting blood glucose measures came from four weekly random glucose tests, using a Bayer glucometer (Bayer, Tarrytown, NY).

Analytic plan

We conducted ANOVAs comparing the CR group with normal weight and overweight/obese comparisons on the above psychosocial and physiological measures (Table 2). If significant differences emerged between groups, we used post hoc Tukey's tests to probe these differences. Because CR duration ranged from 2 to 33 years, we conducted regression analyses using years of CR as a continuous predictor variable (Table 3) for each outcome. As older restrictors have had more years to sustain CR, we controlled for age. Additionally, to increase power given our sample size, we conducted two-group ANOVAs between the CR group and all compari-

Table 1
Characteristics of the study sample ($n = 65$).

Variable		M (SD) or %
Age (years)		54.95 (14.36)
Gender		
	Male	78.5
	Female	21.5
Ethnicity		
	White	86.2
	Black/African American	0
	Hispanic/Latino	1.5
	American Indian/Alaska Native	3.1
	Asian/Pacific Islander	7.7
	Other	1.5
Education		
	High School Graduate/GED	1.5
	Some College	10.8
	Associate's Degree	1.5
	Bachelor's Degree	29.2
	Master's Degree	16.9
	Professional/Doctoral Degree	40.0

M, mean; *SD*, standard deviation.

sons; doing so revealed similar patterns of results (see supplementary Table S1 in the online version at doi:10.1016/j.appet.2014.04.006).

Results

Results reflect analyses on 28 CR participants and 15 normal weight and 22 overweight comparison participants with complete data (demographics Table 1). The CR group reported significantly higher income than comparison groups ($F(2, 57) = 4.45$, $p < .02$), particularly overweight comparison ($p < .01$). Intelligence scores were equal among the three groups ($F(2, 62) = 1.16$, $p < .32$; Table 2), but the average ($M = 26.57$, $SD = 6.89$) was above the population mean of 20 (Blackwell, 2001).

Verification of self-report behavior

The CR group engaged in long-term CR, measuring lower than both comparison groups on BMI ($F(2, 64) = 86.75$, $p < .001$), fasting blood glucose ($F(2, 53) = 11.33$, $p < .001$), and daily kilocalorie consumption ($F(2, 56) = 7.28$, $p < .001$). The average length of CR practice was 10 years ($SD = 7.23$, range = 2–33). Regression analyses indicated significant negative relationships between years of CR practice and BMI ($\beta = -.60$, $p < .001$), fasting blood glucose ($\beta = -.36$, $p < .004$), and daily calorie consumption ($\beta = -.33$, $p < .01$). The CR group also scored significantly higher than both comparison groups on the EDE-Q measure of restriction ($F(2, 64) = 7.96$, $p < .001$) and DEBQ measure of restraint ($F(2, 64) = 22.71$, $p < .001$). Table 2 displays three-group comparisons.

Aim 1: Test whether the CR group differs from comparison groups in eating disorder and other psychopathology symptomatology

The CR group scored significantly differently from comparison groups on the CES-D ($F(2, 58) = 7.57$, $p < .001$), EDE-Q shape concern subscale ($F(2, 64) = 13.60$, $p < .001$), and EDE-Q weight concern subscale ($F(2, 64) = 13.86$, $p < .001$) with post hoc tests revealing significantly lower scores in the CR versus overweight/obese group ($p < .01$). Of the CR individuals 10.7% ($n = 3$) exceeded the CES-D cutoff of 16 for risk of clinical depression, which was less than the 18.9% of comparison participants ($n = 7$) who exceeded this cutoff ($F(2, 58) = 13.45$, $p < .001$). Additionally, on the three EDE-Q questions with 4 being the cutoff for eating disorder indications, only 3.6%, 3.6%, and 7.2% of CR participants ($n = 1, 1, 2$; three individuals) exceeded 4, which was less than comparisons ($F(2, 64) = 5.92$, $p < .01$). Post hoc tests demonstrated a significant difference between the CR group and overweight/obese comparisons ($p < .05$). There was no significant difference between the CR and comparison groups on the MOCI ($F(2, 64) = 1.66$, $p < .20$), DEBQ emotional eating ($F(2, 64) = .63$, $p < .54$) or EDE-Q eating concern ($F(2, 64) = 2.94$, $p < .06$; Table 2).

Table 2
Three-group ANOVAs and post hoc tests.

Variable	CR M (SD)	Normal weight M (SD)	Overweight/obese M (SD)	F	p	Tukey's post hoc†
BMI	18.99 (1.82)	23.27 (1.78)	29.24 (3.49)	102.85	.00	a < b**, a < c**, b < c**
Glucose	79.77 (9.55)	90.12 (10.56)	96.54 (13.75)	11.33	.00	a < b**, a < c**
Calories	1549.84 (385.74)	2084.82 (611.37)	1970.60 (404.66)	7.28	.00	a < b**, a < c**
Income	6.54 (.91)	5.67 (1.92)	4.95 (2.48)	4.45	.02	a > c**
Depression	6.54 (6.46)	11.29 (7.66)	14.21 (6.12)	7.57	.00	a < c**
OCD	4.32 (3.02)	4.33 (3.75)	6.09 (4.39)	1.66	.20	
Restricted eating	2.59 (2.02)	.77 (.90)	1.28 (1.21)	7.96	.00	a > b**, a > c*
Eating concern	.28 (.70)	.25 (.32)	.72 (.88)	2.94	.06	
Shape concern	.64 (.93)	1.18 (.93)	2.55 (1.8)	13.60	.00	a < c**, b < c**
Weight concern	.53 (.95)	1.05 (.83)	2.26 (1.55)	13.86	.00	a < c**, b < c**
Retrained eating	3.89 (.65)	2.87 (.60)	2.87 (.53)	22.71	.00	a > b**, a > c**
External eating	2.51 (.48)	3.10 (.56)	3.15 (.54)	11.59	.00	a < b**, a < c**
Emotional eating	2.10 (.76)	2.24 (.46)	2.34 (.86)	.63	.54	
Hostility	10.57 (4.94)	13.47 (6.23)	17.41 (9.67)	5.64	.01	a < c**
Openness	4.31 (.78)	4.01 (.39)	4.22 (.63)	1.13	.33	
Neuroticism	2.03 (.84)	2.35 (.53)	2.56 (.65)	3.50	.04	a < c*
Conscientiousness	3.99 (.76)	3.65 (.53)	3.66 (.59)	2.05	.14	
Extraversion	3.17 (.81)	3.05 (.73)	3.28 (.77)	.40	.67	
Agreeableness	3.98 (.72)	3.98 (.77)	3.67 (.62)	1.42	.25	
Past-negative	2.15 (.66)	2.67 (.48)	2.83 (.63)	8.39	.00	a < b*, a < c**
Present-hedonic	2.82 (.48)	3.27 (.55)	3.10 (.43)	4.74	.01	a < b*
Future	3.87 (.48)	3.62 (.45)	3.53 (.40)	3.84	.03	a > c*
Present-fatalistic	2.00 (.53)	2.53 (.68)	2.44 (.54)	5.67	.01	a < b*, a < c*
Past-positive	3.60 (.70)	3.89 (.48)	3.54 (.61)	1.59	.21	
Intelligence	28.07 (7.00)	25.79 (8.01)	25.23 (5.87)	1.16	.32	

* $p < .05$. ** $p < .01$.
M, mean; *SD*, standard deviation; *F*, Fisher's *F* ratio.
† a = CR, b = Normal Weight, c = Overweight.

Aim 2: Test whether the CR group differs from comparison groups along key psychosocial dimensions

Regarding social relationships, CR participants mentioned on average 2.30 (*SD* = 2.22) close others, and 19 (70.4%) mentioned two or fewer. Four CR participants (14.8%) mentioned no significant relationships, 22 (81.5%) mentioned no friends, and six (21.4%) described themselves as "loners," "solitary," or having little in- person social interaction. Finally, all but one (96.3%) mentioned two or fewer social hobbies. Comparison groups reported similar social profiles but generally indicated higher numbers. Only three (8.1%) mentioned no specific social relations and only two (5.4%) described themselves as "loners," "solitary," or having little in- person social interaction.

The CR group scored differently from comparisons on ZTPI future perspective ($F(2, 64) = 3.84$, $p < .03$), and post hoc tests showed the CR group scored significantly higher than overweight/obese comparisons ($p < .05$). Additionally, the CR group scored differently on the Cook–Medley Hostility Scale ($F(2, 64) = 5.64$, $p < .01$) with post hoc tests revealing significantly lower scores than overweight/obese comparisons ($p < .01$). For neuroticism, the CR group showed significantly different scores ($F(2, 64) = 3.5$, $p < .04$), and post hoc tests revealed lower scores than overweight/obese comparison ($p < .04$). The ZTPI past-negative perspective model was also significant ($F(2, 64) = 8.39$, $p < .001$), with post hoc tests showing CR scores significantly lower than normal weight ($p < .05$) and overweight/obese ($p < .01$) comparisons. The ZTPI present-fatalistic time perspective revealed different scores for the CR group ($F(2, 64) = 5.67$, $p < .01$), with post hoc results lower than normal weight ($p < .05$) and overweight/obese ($p < .05$) comparisons. The ZTPI present-hedonic time perspective model was significant ($F(2, 64) = 4.74$, $p < .01$), and post hoc tests revealed that CR scores were significantly lower than normal weight comparisons ($p < .05$). There were no significant differences for other personality dimensions (openness, extraversion, agreeableness) or past-positive perspective. The CR group scored significantly lower than normal weight ($p < .01$) and overweight/obese comparisons ($p < .01$) on DEBQ external eating ($F(11.59) = 23.43$, $p < .001$); see Table 2.

Aim 3: Determine whether there is a relationship between duration of CR and psychosocial characteristics and eating behavior

In multiple regression analyses using years of CR as a continuous predictor (Table 3), significant negative associations emerged with hostility ($\beta = -.35$, $p < .01$), neuroticism ($\beta = -.37$, $p < .003$), past-negative time perspective ($\beta = -.43$, $p < .001$), present-fatalistic time perspective ($\beta = -.44$, $p < .001$), and present-hedonic time perspective ($\beta = -.36$, $p < .004$). Significant positive associations emerged between years of CR and conscientiousness ($\beta = .29$, $p < .02$) and future time perspective ($\beta = .26$, $p < .04$).

Table 3
Regression analyses with years of CR.

Variable	β	*p*
BMI	–.60	.00
Glucose	–.36	.00
Calories	–.33	.01
Depression	–.39	.00
OCD	–.14	.28
Restricted eating	.34	.01
Eating concern	–.19	.15
Shape concern	–.39	.00
Weight concern	–.39	.00
Retrained eating	.56	.00
External eating	–.49	.00
Emotional eating	–.19	.14
Hostility	–.35	.01
Openness	.21	.11
Neuroticism	–.37	.00
Conscientiousness	.29	.02
Extraversion	.04	.76
Agreeableness	.15	.24
Past-negative	–.43	.00
Present-hedonic	–.36	.00
Future	.26	.04
Present-fatalistic	–.44	.00
Past-positive	.52	.60
Intelligence	.24	.07

Note: All analyses control for age.

Discussion and conclusions

In this unique sample of long-term calorie restrictors, we found that the participants' eating-related thoughts and behaviors did not indicate eating disorder pathology. Considering the link between CR and eating disorders (e.g., Fairburn & Harrison, 2003; Heatherton & Polivy, 1992), our results suggest that certain psychosocial profiles may be protective of eating disorder pathology in the context of an otherwise risk factor of extreme CR. These long-term calorie restrictors, however, were not ordinary individuals: compared with free-eating normal weight and, in particular, overweight/obese individuals, the CR group demonstrated strong future time orientations and low hostility, neuroticism, and responsiveness to external eating cues. The CR group's duration of CR was also associated with these characteristics and negatively related to kilocalorie intake, leaving open the intriguing possibility that unlike typical dieters (Jeffery et al., 2000), these CR individuals may even *improve* at restriction over time.

The CR group's time perspectives were also revealing. Their strong future orientation with low present-hedonistic and fatalistic orientations paralleled structured interview responses: CR participants listed future-oriented motivations for initiating and sustaining their CR, including health and longevity. One participant was even planning a 130th birthday celebration 70 years in advance. Extreme future orientations, however, may come at a price. Zimbardo and Boyd note that future-oriented motivations can undermine social relationships (Zimbardo & Boyd, 1999). This appears to be the case as the interviews revealed a paucity of social relationships and activities among CR participants.

Because of the cross-sectional design, we cannot rule out reverse causation – that long-term CR changes psychosocial profiles – or a third variable driving the results. Income, for example, was higher in the CR group than in the comparison groups, which may provide resources enabling long-term dieting and promoting this psychological profile. We suspect, however, that a 10-year randomized, controlled experiment to determine causation is infeasible as 2 years appears to be the upper limit for studies with random assignment to long-term CR (Rochon et al., 2010). Therefore, in the context of our cross-sectional design, we employed two strategies to understand the potential causality. First, we compared the CR group to matched groups of nonrestricting normal weight and overweight/obese individuals. Second, we chose measures that the literature identifies as relatively crystallized. Nonetheless, longitudinal research is necessary and could clarify these stable constructs as predictors of long-term dieting capability. Along with these points, as with all self-report measures, we acknowledge that CR results may reflect response biases. CR participants may have intentionally or unintentionally attempted to suppress or highlight characteristics to reflect most positively on their lifestyle. Individuals often underreport their calorie consumption to reflect socially desirable eating (Schoeller, Bandini, & Dietz, 1990). Therefore, our verification of CR by objective measures such as fasting blood glucose represents a marked strength of this study. Finally, because we chose such a unique group, our sample size was small and tests may have been underpowered. Perhaps as an indication of this, the significant differences we observed were primarily among extremes (CR and

overweight/obese). Future research can verify this pattern in larger samples.

Although sample size appears to be a limitation, this study represents the largest cohort of this group ever to be studied, which may be telling in itself: The fact that identifying successful long-term calorie restrictors is so difficult indicates just how rare successful dieters are. Another potential data point – rather than biased sampling – is that our sample was mostly white, highly educated, wealthy males, suggesting males perhaps have certain biological characteristics facilitating long-term CR. Consistent with this interpretation, the increased progesterone in women during the last week before menstruation and during pregnancy often leads to increased appetite (Rodin, Silberstein, & Striegel-Moore, 1985). Regarding education, the percentage of our sample holding a doctoral or professional degree – nearly 40% – is certainly not representative of the general population. Because we matched the comparison groups on the CR group's demographic characteristics, the comparison groups themselves were not representative and generalizability was therefore somewhat limited.

Despite some limitations, we believe these findings offer novel insight into what characterizes a successful chronic calorie restrictor especially compared with overweight/obese individuals. It appears that individuals who succeed at long-term CR possess unique personality and demographic characteristics that may predispose them to dieting success: earning a higher income, valuing the future highly and perhaps at the expense of a rich social life, being highly conscientious, and low in neuroticism. This psychosocial profile may be uncommon among obese individuals, who are those most likely to pursue CR for weight-loss, as our overweight/obese comparison group showed the most significantly different profiles from the CR group. For instance, obesity rates are highest among low-income populations (Baum & Ruhm, 2009), but our successful restrictors had high income.

Overall, these results may have important treatment implications. Rather than widely recommending CR for weight-loss, as is common among clinicians and general practitioners (van Dillen et al., 2013), and rather than blaming dieting failure on the dieter, these results suggest CR may be a viable and recommendable option for only a small, unique subset. Paralleling a movement in healthcare toward personalized medicine, our findings highlight the need to move toward a personalized *behavioral* medicine model in treating overweight/obesity. Just as pharmaceutical treatments work best with certain genotypes, behavioral treatments may work only for individuals with certain psychosocial phenotypes. These results may also direct behavioral nutrition research in developing eating plans tailored to each individual's particular psychosocial profile. With diseases of overconsumption at epidemic levels and successful long-term CR often unattainable, our findings set the stage for future investigations into success and failure at long-term CR to ultimately evaluate if dieting can effectively combat the obesity epidemic.

Appendix: Supplementary material

Supplementary data to this article can be found online at doi:10.1016/j.appet.2014.04.006

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