Maca reduces blood pressure and depression, in a pilot study in postmenopausal women

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ABSTRACT

Objective *Lepidium meyenii* (Maca) has been used for centuries for its fertility-enhancing and aphrodisiac properties. In an Australian study, Maca improved anxiety and depressive scores. The effects of Maca on hormones, lipids, glucose, serum cytokines, blood pressure, menopausal symptoms and general well-being in Chinese postmenopausal women were evaluated.

Methods A randomized, double-blind, placebo-controlled, cross-over study was conducted in 29 postmenopausal Hong Kong Chinese women. They received 3.3 g/day of Maca or placebo for 6 weeks each, in either order, over 12 weeks. At baseline, week 6 and week 12, estradiol, follicle stimulating hormone (FSH), sex hormone binding globulin (SHBG), thyroid stimulating hormone (TSH), full lipid profiles, glucose and serum cytokines were measured. The Greene Climacteric, SF-36 Version 2, Women's Health Questionnaire and Utian Quality of Life Scales were used to assess the severity of menopausal symptoms and health-related quality of life.

Results There were no differences in estradiol, FSH, TSH, SHBG, glucose, lipid profiles and serum cytokines amongst those who received Maca as compared to the placebo group; however, significant decreases in diastolic blood pressure and depression were apparent after Maca treatment.

Conclusions Maca did not exert hormonal or immune biological action in the small cohort of patients studied; however, it appeared to reduce symptoms of depression and improve diastolic blood pressure in Chinese postmenopausal women. Although results are comparable to previous similar published studies in postmenopausal women, there might be a cultural difference among the Chinese postmenopausal women in terms of symptom reporting.

INTRODUCTION

Hormone replacement therapy (HRT) is the most effective treatment for the relief of menopause symptoms, yet many women have become reluctant to continue or commence HRT due to fear of adverse risks[1]. Instead women seek alternative treatment options, particularly complementary and alternative therapies[2]. A study conducted in Australian women revealed that over 50% of respondents had used complementary and alternative medicines or had visited a practitioner for the alleviation of menopausal symptoms. Further, following the release of the Women's Health Initiative Study indicating that HRT was associated with adverse health risks[3], there has been an increase in the number of dietary supplements manufactured specifically to target menopausal women[4].

Numerous alternative therapies currently available claim to provide a wide array of benefits to menopausal women, of which some, including soy and black cohosh, have been supported by scientific evidence[4]. There are, however, numerous products for which benefit has been claimed although scientific support is lacking[2]. Maca is one example. Maca is a herbaceous biennial plant, the root of the plant *Lepidium meyenii*; it is grown exclusively at high altitude (3800–4400 m above sea level) in the Andes region of Peru and Bolivia, where

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it is widely used for its putative fertility-enhancing and aphrodisiac properties[5].

Maca is marketed commercially for its reported benefit in relieving menopause symptoms, although there are scant published scientific data to support any efficacy[6]. Initial research has focussed on a possible role for Maca in improving male fertility[7–14] with emerging evidence that Maca may improve sperm production and quality[7]. Although few studies have as yet examined the effect of Maca in women, data from oophorectomized rats suggest that Maca can improve bone mass and restore the trabecular network in the lumbar vertebrae, findings relevant to the high risk of osteoporosis many women face after menopause[15].

The mechanisms by which Maca may affect the male or female reproductive system remain to be elucidated. The possibility of estrogenic effects is based on the fact that Maca contains the phytoestrogen β-sitosterol[13]. Several studies, however, have been unable to detect *in vivo* estrogenic effects[9,10,13], although one study has reported that Maca extracts promote proliferation of MCF-7 cells, an estrogen receptor-positive human breast cancer cell line[16]. Alkaloids, isothiocynates and glucosinolates are also potential active constituents of Maca[15]. One constituent, namely the glucosinolate indoly-3-methyl (glucobrassicin), may modulate androgenic activity as it can be enzymatically hydrolyzed to 3,3-diindolylmethane (DIM), known as a specific antagonist of the androgen receptor[17,18]. To our knowledge, DIM is the first example of a pure androgen receptor antagonist from plants[18].

This study seeks to examine the effect of *Lepidium meyenii* (Maca) on the hormonal profile and symptoms in Chinese (Hong Kong) postmenopausal women. In a randomized, crossover design study, serum sex hormone levels, thyroid stimulating hormone (TSH), sex hormone binding globulin (SHBG), glucose, cytokines and lipid concentrations were measured in 29 postmenopausal women. Furthermore, as women often report that Maca is beneficial in alleviating menopausal symptoms, changes in menopausal symptoms were also examined in our study using the Greene Climacteric Scale, the SF-36 Version 2, the Women's Health Scale and the Utian Quality of Life Scale, all well-validated questionnaires. Although a similar methodology as described in this study has been used previously in Caucasian postmenopausal women[19], to our knowledge this is the first study examining the effects of Maca in a small cohort (pilot study) of Chinese women from Hong Kong, which is a different cultural and ethnic group.

METHODS

Subjects

Thirty-four healthy postmenopausal women aged between 46 and 59 years, who were currently experiencing symptoms of menopause, recruited by newspaper advertisement, participated in this study. All women were amenorrheic for 12 months or longer. Subjects were excluded from the study if they were currently on HRT or had taken HRT within the last 6 months, if they had a cardiac, renal, hepatic, inflammatory or psychiatric condition, or if they regularly consumed more than two standard alcoholic drinks each day. Subjects were also excluded if they currently consumed Maca supplements, or other Chinese or alternative medicine supplements for the relief of menopausal symptoms. Subjects were required not to consume any dietary supplements or Chinese herbal therapies for the duration of the study.

Study design

The study protocol was approved by the Clinical Research Ethics Committee of the Chinese University of Hong Kong and written informed consent was obtained from all participants. This was a 12-week, randomized, single-center, double-blinded, placebo-controlled, cross-over trial. A completely randomized factorial design method was used and a researcher not involved with the study kept the study staff blinded to participants' treatment order. The sample size for this study was based on previous results published by the principal investigator[19]. Twenty-nine out of 34 women completed the trial. Fifteen women commenced the Maca treatment first and 14 women commenced the placebo treatment first. Each subject received 3.3 g/day Maca or placebo of identical appearance and packed identically in capsulated form, for 6 weeks, in random order, with the entire study extending over a period of 12 weeks. The recommended and safe dose of Maca is up to 4 g daily. Women in this study were consuming 3.3 g/day which is just below or equivalent to the daily recommended dose on the package of our supplier, and is based on previous human studies[8,9,19]. At baseline, week 6 and week 12, venous blood samples were collected for the measurement of serum estradiol, follicle stimulating hormone (FSH), SHBG, thyroid stimulating hormone (TSH), full lipid profiles, glucose and serum cytokines. At baseline, week 6 and week 12, women also completed the Greene Climacteric Scale (GCS) and SF-36 Version 2, quality-of-life questionaries to determine whether there had been any change in the severity of their physiological and psychological symptoms as well as changes in quality of life. Determinations of height, body weight and blood pressure were also taken at these three time points. Maca is a root of the plant *Lepidium meyenii* cultivated high in the Andean Mountains and comes prepared to us in capsulated form (Maca Power, Healthychoices, Murwillumbah, NSW, Australia), with each capsule containing 462 mg net Maca. Maca root also contains amino acids, complex carbohydrates, vitamins B1, B2, C, E and minerals. A placebo of matching color and consistency (refined white rice flour) was provided in an identical dose and packaging. Subjects were asked to consume one 3.3 g dose consisting of seven capsules of Maca or placebo per day, four capsules following breakfast and three following dinner, to ensure uniform concentration throughout the 24-h cycle. For convenience, daily and weekly doses were packed in plastic sachets. Participants' compliance with treatment was monitored. They were required to bring in any unused capsules at the next scheduled visit.

Measurements

Serum estradiol, FSH, SHBG, TSH and lipids were analyzed by the pathology laboratory (Prince of Wales Hospital, New Territory, Hong Kong). Serum estradiol, FSH and TSH were analyzed using the Roche E170 immunoassay analyser with ECLIA technology (Roche Diagnostics, Indianapolis, IN, USA). Mean intra-assay and inter-assay coefficients of variation for the TSH assay were 1.2% and 4.0%, for the estradiol assay 1.6% and 6.4%, and for the FSH assay 1.7% and 4.4%, respectively.

SHBG was determined using a solid-phase chemiluminescent immunometric assay measured on the Immulite 1000 SHBG immunoassay system (Simens Medical Solution Diagnostics, Los Angeles, CA, USA). Mean intra-assay and inter-assay coefficients of variation for the SHBG assay were 4.5% and 5.7%, respectively.

Serum lipids were measured with a calorimetric test using DP Modular Analytics, with mean intra-assay and inter-assay coefficients of variation for cholesterol and high density lipoprotein (HDL) cholesterol assays of 1.7% and 1.9%, respectively, while for triglycerides the intra-assay and inter-assay coefficients of variation were 1.2% and 2.8%, respectively.

Cytokines (interleukin (IL)-2, IL-4, IL-5, IL-10, IL-12 (p70), IL-13, granulocyte macrophage colony-stimulating factor (GM-CSF), interferon gamma (IFN-γ) and tumor necrosis factor alpha (TNF-α)) were detected simultaneously in plasma samples using a multiplex premixed human cytokine Th1/Th2 assay (Bio Rad, VIC, Australia) according to the manufacturer's instructions. Briefly, serial dilutions of the reconstituted premixed standards were performed using standard diluent, resulting in a standard curve. Samples were also diluted 1 : 4 in appropriate diluent. Standards and samples were subsequently incubated in 96-well plates with anti-human, antibody-coated beads provided. Removal of unbound protein was facilitated by a series of three washes using the Bio-plex vacuum manifold system and wash buffer. Biotinylated secondary and streptavidin-phycoerythrin antibodies were then sequentially bound to the beads to enable cytokine detection. Finally, the assay plates were loaded into a Bio-plex array reader to detect bound cytokines, and data analyzed using the Bio-plex manager software.

Plasma glucose measurements were conducted at Victoria University's sports performance laboratory, Footscray Park, Melbourne, using a YSI 2300 STAT plus glucose analyzer (YSI). Frozen samples were thawed and vortexed to resuspend components prior to presenting each sample to the YSI sipper arm. The YSI ran an automatic calibration after every ten samples. Plasma glucose definitions were based on World Health Organization (WHO)diagnostic criteria (2006), namely diabetes as fasting plasma glucose of ≥ 7.0 mmol/l, and impaired fasting glucose as fasting plasma glucose of 6.1–6.9 mmol/l.

The Greene Climacteric Scale (GCS) is a well-validated, non-intrusive, self-report questionnaire that measures the physical and psychological symptoms associated with menopause. The scale assesses psychological symptoms, with subscales for anxiety and depression, somatic symptoms, vasomotor symptoms, and sexual dysfunction. A total score is also calculated[20]. Test reliability for the subscales ranges from 0.83 for the vasomotor scale to 0.87 for the psychological scale[20,21].

The SF-36 Health Survey, developed by Ware and colleagues and subsequently modified (SF-36 Version 2) by the same authors in 1976[22], is the most widely used health-related quality of life measure world-wide, including Hong Kong, with over 4000 publications[23]. The survey includes 36 items summarized into eight multi-item scales, along with one item of health change: physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional and mental health[23,24]. SF-36 has been translated and validated in more than 22 countries, including for the Chinese population in Hong Kong. Reliability estimates for physical and mental summary scores usually exceed 0.90[25]. Test reliability for the subscales is more than 0.80 (with 0.93 for mental health), except for social functioning, which has a median reliability of 0.76[25].

The Women's Health Questionnaire (WHQ) was developed in the 1980s by Myra Hunter at London University[26]. The WHQ contains 36 questions assessing nine domains of mental and physical health, rated on a 4-point scale, and was developed specifically for women during the menopause transition and is available in 27 languages. WHQ measures the following subclasses: depressed mood, somatic symptoms, sleep problems, anxiety/fears, sexual behavior, vasomotor symptoms, menstrual symptoms, memory/concentration and attractiveness. Test reliability ranges from 0.78 to 0.96, suggesting that the WHQ is a highly reliable measure for mid-aged women's emotional and physical health[27].

The Utian Quality of Life (UQOL) Questionnaire is a quick 2-page (5-minute), 23-item, validated questionnaire that clinicians use, for clinical or research purposes, to understand a woman's menopause-related quality of life[28]. The UQOL Scale assesses occupational, health, emotional, and sexual quality of life and the test reliability ranges from 0.88 to 0.91[29].

Statistical analysis

Statistical analyses were performed using SPSS (version 16.0, SPSS Inc., Chicago, USA). All data are expressed as the mean ± standard deviation. Data were first assessed for normality using the Kurtosis test. Analyses of hormone levels, GCS, SF-36 Version 2 and body weight were performed using one-way repeated measures analysis of variance (ANOVA) with Tukey significance difference as a *post hoc* analysis account for paired data. A p value of < 0.05 was considered of statistical significance. One-way ANOVA analyses using treatment order as a between-subjects factor indicated that there was no carry-over effect in any of the measured variables.

RESULTS

Study population

Seventy-five women responded to an advertisement in a local Chinese newspaper. Following initial telephone screening, 34 women were recruited, of which 29 women completed the trial. Five participants dropped out of the study within the first 4 weeks of commencement, one woman went on a prolonged overseas trip, two became disinterested in the study, whilst two women dropped out due to time constraints. Data have therefore been analyzed for a total of 29 women only, and the study is considered a small pilot study.

At the commencement of the study, the mean age of participants was 52.4 ± 2.7 years (mean $\pm$ standard deviation); they had median duration of amenorrhea of 26.4 ± 11.2 months and mean body mass index (BMI) of 23.2 ± 3.1 kg/m^2. It is generally accepted that BMI between 18.5 and 25 kg/m^2 indicates a normal healthy weight, with 25–30 kg/m^2 indicating overweight and >30 kg/m^2 being obese, in the western world. However, there are international variations, set by the WHO guidelines; in the Asian population, the healthy BMI range is 18.5–22.9 kg/m^2, with 23–24.9 kg/m^2 being overweight and >25 kg/m^2 considered obese. Hence, a proportion of the subjects were in the overweight and obese range. During the study, both body weight and BMI did not change significantly (Table 1).

Hormone profile

Anthropometric measures, serum hormone levels of estradiol, FSH, SHBG, TSH and lipid profile were measured at baseline, 6 and 12 weeks (Table 2). Spatial decreases in systolic ($p = 0.05$) and diastolic ($p = 0.01$) blood pressures were detected after 6 weeks of Maca; these were statistically significant over baseline levels (Table 2). However, a systolic blood pressure decrease was also noted in the placebo group, which was significant compared to baseline levels. No statistically significant changes in serum hormone levels or SHBG were noted ($p > 0.05$). *Post hoc* analysis, however, showed that our study is only powered to detect a significance at $p = 0.8$ and $\lambda = 0.05$, a 15% increase in estradiol.

Physiological measurements

The Th1 and Th2 cytokines, the main cytokines involved in humoral and cellular immunity, were assessed to determine whether Maca intake had an effect physiologically (at the cellular level). Three cytokines (IL-5, IL-10 and IL-13) were detectable within range at the lower end, whilst six cytokine measures (IL-2, IL-4, IL-12, GM-CSF, IFN-γ, TNF-α) were found to be in concentrations beyond the detectable range (OOR<). For analysis purposes, OOR< (undetectable) readings were included in calculations as zero values. Our results indicate that there was minimal variation in detectable cytokines between baseline, the placebo and Maca-supplemented groups and these variations were not statistically significant when applied to the Student *t*-test (data not shown).

The mean fasting plasma glucose for this cohort was slightly elevated in both placebo and Maca treatments when compared to values at baseline, but this was negligible and not statistically significant (data not shown). At baseline, 2/27 patients had impaired fasting glucose levels as defined by WHO (2006). The fasting plasma glucose for these patients decreased with placebo as well as with Maca treatment; however, these changes were not statistically significant (data not shown), the study group is too small, and other factors apart from impaired glucose tolerance may have contributed to elevated plasma glucose at baseline in those subjects. Similar studies in a larger cohort with known impaired glucose tolerance may be warranted as to Maca's effect on plasma glucose.

Greene Climacteric Scale

The scores on the Greene Climacteric Scale (GCS) are shown in Table 3. The psychological scale indicated that Maca treatment was associated with a significant reduction in symptom scores (30% reduction from baseline values, $p < 0.05$) and after treatment with placebo (27% less than after placebo, $p < 0.05$). The psychological scale contained two subgroups, anxiety and depression. Results for the anxiety scale show a significant reduction in scores following Maca treatment compared to baseline (30.8% reduction, $p < 0.05$), and values after treatment with placebo (27.3% decrease, $p < 0.05$). The

Table 1 Body weight and body mass index during the randomized, cross-over design study ($n = 29$). Data are given as mean $\pm$ standard deviation

				Repeated measures	
Treatment order	*Baseline*	*6 weeks*	*12 weeks*	*Lambda*	*p Value*
Maca then placebo ($n = 15$)					
Body weight (kg)	57.7 ± 8.4	57.8 ± 8.3	58.1 ± 8.4	0.83	0.29
Body mass index (kg/m^2)	23.2 ± 3.3	23.3 ± 3.2	23.4 ± 3.3	0.77	0.18
Placebo then Maca ($n = 14$)					
Body weight (kg)	56.8 ± 8.5	56.6 ± 8.6	56.5 ± 8.5	0.84	0.36
Body mass index (kg/m^2)	22.6 ± 3.2	22.5 ± 3.1	22.5 ± 3.1	0.88	0.46

Table 2 Mean values of anthropometric measurements, serum hormones and lipids at baseline, following Maca and following placebo. Data are given as mean ± standard deviation ($n = 29$)

	Baseline	*After 6 weeks of Maca*	*After 6 weeks of placebo*	*Repeated measures*	
				Lambda	*p Value*
Weight (kg)	57.3 ± 8.3	57.2 ± 8.3	57.4 ± 8.4	0.96	0.54
Body mass index (kg/m^2)	22.9 ± 3.2	22.9 ± 3.1	23.0 ± 3.2	0.96	0.55
Systolic blood pressure (mmHg)	132.5 ± 18.2	125.6 ± 19.8*	126 ± 16.3*	0.80	0.05*
Diastolic blood pressure (mmHg)	81.8 ± 13.1	73.8 ± 10.6*	77.7 ± 12.5	0.69	0.01*
Heart rate (beats/min)	66.5 ± 9.4	68.8 ± 7.8	65.6 ± 6.0	0.81	0.06
Estradiol (pmol/l)	46.3 ± 8.6	48.3 ± 12.5	49.5 ± 18.7	0.93	0.40
Follicle stimulating hormone (IU/l)	77.5 ± 19.0	79.9 ± 23.6	75.5 ± 19.7	0.96	0.55
Sex hormone binding globulin (nmol/l)	47.6 ± 29.5	47.8 ± 26.7	48.8 ± 35.9	0.99	0.90
Thyroid stimulating hormone (mIU/l)	1.94 ± 1.4	2.1 ± 1.4	2.0 ± 1.3	0.93	0.40
Cholesterol (mmol/l)	5.4 ± 0.8	5.5 ± 0.9	5.5 ± 0.9	0.98	0.81
High density lipoprotein cholesterol (mmol/l)	1.6 ± 0.5	1.64 ± 0.4	1.56 ± 0.4	0.82	0.09
Low density lipoprotein cholesterol (mmol/l)	3.2 ± 0.8	3.3 ± 0.8	3.3 ± 0.9	0.91	0.32
Triglycerides (mmol/l)	1.4 ± 0.8	1.26 ± 0.56	1.4 ± 0.7	0.92	0.36
Non-high density lipoprotein cholesterol (mmol/l)	3.9 ± 0.8	3.9 ± 0.9	4.1 ± 0.9	0.96	0.64

*, Significant difference from baseline ($p < 0.05$)

second subscale measured depression where again a significant reduction in scores was seen following Maca treatment in comparison to either baseline or after placebo (28.9% and 26.8%, respectively, both $p < 0.05$). In addition, somatic symptoms were significantly decreased by 27% ($p < 0.05$) compared to baseline.

The GCS also allows for a total score to be calculated. Maca decreased total scores by 22.5% in comparison to baseline ($p = 0.07$); however, a significant reduction was noted in the placebo group with a 26% reduction ($p < 0.04$). There were no significant changes seen in sexual dysfunction, vasomotor and urinary scores during the trial.

SF-36 Version 2

The mental and physical health of all participating subjects were assessed. Following Maca treatment, patients clearly reported a significant increase in their overall health functioning, in particular, general well-being (10.8% increase, $p < 0.05$) and mental health (13.5% increase, $p < 0.05$) (Table 4); however, similar increases were noted following placebo. Following placebo, social functioning (16.4% increase, $p < 0.05$), and the mental component score (13% increase, $p < 0.05$) were significantly increased compared with baseline. There were no statistical differences in physical functioning, role physical, body pain, vitality, role emotional and in the physical component score (Table 4).

Women's Health Questionnaire Scale

Nine domains of mental and physical health of all participating subjects were assessed. Following Maca , patients clearly reported statistically significant (34–36%, $p < 0.05$) decreases in depression and anxiety/fears. Similarly, placebo showed a

Table 3 Mean values of scores on the Greene Climacteric Scale at baseline, following Maca and following placebo. Data are given as the mean ± standard deviation ($n = 29$)

	Baseline	*After 6 weeks of Maca*	*After 6 weeks of placebo*	*Repeated measures*	
				Lambda	*p Value*
Psychological	12.3 ± 5.9	9.3 ± 5.6*	9.0 ± 5.5*	0.68	0.01*
Anxiety	6.7 ± 3.5	5.1 ± 3.3*	5.0 ± 3.0 *	0.73	0.02*
Depression	5.5 ± 3.0	4.2 ± 2.6*	4.0 ± 3.0*	0.69	0.01*
Somatic	5.5 ± 3.3	4.7 ± 3.5	4.0 ± 3.2*	0.77	0.03*
Vasomotor	2.4 ± 1.4	2.4 ± 1.7	2.6 ± 1.6	0.99	0.77
Sexual dysfunction	1.5 ± 0.9	1.2 ± 1.0	1.2 ± 1.0	0.90	0.24
Urinary	2.6 ± 1.4	2.1 ± 1.5	2.0 ± 1.8	0.86	0.14
Total score	22.7 ± 9.9	17.6 ± 10.0 ($p = 0.07$)	16.8 ± 9.1*	0.78	0.04*

*, Significant difference from baseline ($p < 0.05$)

Table 4 Mean values of scores on the SF 36 Version 2 Scale at baseline, following Maca and following placebo. Data are given as the mean ± standard deviation ($n = 29$)

	Baseline	After 6 weeks of Maca	After 6 weeks of placebo	Repeated measures	
				Lambda	p Value
Physical functioning	49.2 ± 5.9	47.1 ± 8.1	49.5 ± 4.9	0.90	0.25
Role physical	47.6 ± 8.2	46.6 ± 10.0	48.1 ± 8.3	0.95	0.50
Body pain	43.1 ± 9.1	45.8 ± 8.5	45.5 ± 9.1	0.88	0.19
General health	41.7 ± 10.3	46.2 ± 7.9*	45.3 ± 8.5*	0.74	0.02*
Vitality	46.5 ± 11.7	49.7 ± 9.7	50.4 ± 9.9	0.91	0.26
Social functioning	42.7 ± 10.8	47.7 ± 9.2 ($p = 0.08$)	49.7 ± 8.4*	0.62	0.00*
Role emotional	42.8 ± 11.1	43.5 ± 11.5	46.1 ± 10.2	0.82	0.07
Mental health	40.6 ± 10.7	46.1 ± 10.8* ($p = 0.03$)	48.1 ± 9.1* ($p = 0.003$)	0.68	0.01*
Physical component score	48.0 ± 6.7	47.4 ± 6.9	47.7 ± 6.4	0.99	0.86
Mental component score	40.9 ± 11.7	46.2 ± 11.6 ($p = 0.06$)	48.3 ± 10.1*	0.66	0.00*

*, Significant difference from baseline ($p < 0.05$)

significant decrease in anxiety score, as well as somatic symptoms and sleep problems (Table 5). No differences were reported for memory, vasomotor, sexual dysfunction, mental, and attention states (Table 5). Interestingly, in the Greene scale and in the WHQ scale, sexual dysfunction showed non-significant improvement with both Maca and placebo, even though there we have noted a significant improvement in a similar study in a Caucasian population[19].

Utian Quality of Life Questionnaire

The Utian Quality of Life questionnaire in all four domains of occupational, health, emotional and sexual quality of life showed no statistical difference following Maca intake (Table 6).

DISCUSSION

Following the publication in 2002 of the first Women's Health Initiative (WHI) report[30], a dramatic decrease in HRT use resulted world-wide, mainly due to the fear of increased risk of developing breast cancer[31]. As a consequence, a large proportion of women seek alternative and complementary strategies for relief of menopausal symptoms, even though they are not as effective as HRT in treating the climacteric symptoms.

Maca has been used for centuries in the Andes to manage anemia, infertility and hormonal balances in women. However, this is based on the long history of traditional usage and anecdotal information by local population groups. Recently, much interest in the properties of Maca has resulted in research leading to evidence of its medicinal effects in animals and in humans. In mouse and rat studies, Maca has been shown to be effective in the prevention of estrogen-deficient bone loss, and improves glucose tolerance, improves memory impairment, improves sexual behavior, invigorates spermatogenesis, exerts anti-hyperplastic effects on the prostate, and increases litter size in female mice[14,15,32–34]. In bulls, Maca supplementation improved sperm quantity and quality whilst mating behaviors were unaffected[35]. Likewise, in human studies, Maca is associated with improved semen parameters[7], improved sexual

Table 5 Mean values of scores on the Women's Health Questionnaire Scale at baseline, following Maca and following placebo. Data are given as the mean ± standard deviation ($n = 29$)

	Baseline	After 6 weeks of Maca	After 6 weeks of placebo	Repeated measures	
				Lambda	p Value
Depression	0.33 ± 0.25	0.21 ± 0.20*	0.23 ± 0.20	0.78	0.04*
Somatic	0.47 ± 0.26	0.41 ± 0.26	0.31 ± 0.25*	0.70	0.01*
Memory	0.69 ± 0.37	0.57 ± 0.37	0.60 ± 0.33	0.87	0.16
Vasomotor	0.57 ± 0.32	0.55 ± 0.43	0.52 ± 0.39	0.99	0.87
Anxiety	0.38 ± 0.30	0.18 ± 0.25*	0.22 ± 0.31*	0.63	0.00*
Sexual dysfunction	0.62 ± 0.40	0.51 ± 0.39	0.52 ± 0.57	0.93	0.37
Sleep	0.53 ± 0.36	0.43 ± 0.40	0.34 ± 0.37*	0.81	0.05*
Mental	0.24 ± 0.34	0.21 ± 0.27	0.24 ± 0.31	0.99	0.86
Attention	0.67 ± 0.36	0.62 ± 0.34	0.60 ± 0.39	0.92	0.60

*, Significant difference from baseline ($p < 0.05$)

Table 6 Mean values of scores on the Utian Quality of Life Scale between Maca and placebo. Data are given as the mean ± standard deviation ($n = 29$)

	After 6 weeks of Maca	*After 6 weeks of placebo*	*Repeated measures*	
			Lambda	*p Value*
Occupation	22.0 ± 5.6	21.4 ± 6.5	0.99	0.53
Health	21.4 ± 3.2	21.4 ± 3.3	1.00	0.97
Emotion	19.0 ± 3.6	19.2 ± 4.4	1.00	0.86
Sexual	8.4 ± 2.4	8.7 ± 3.1	0.99	0.55
Total	70.8 ± 10.2	70.8 ± 13.0	1.0	0.99

desire in men[9] with no relationship to testosterone levels[8], is helpful for erectile dysfunction[36], and improved symptoms of female sexual dysfunction[37]. Maca has also been noted to increase testosterone levels in females regularly consuming Maca[38]. We previously reported, in 14 postmenopausal women in a randomized, double-blind, placebo-controlled, cross-over trial, that Maca had beneficial effects on psychological symptoms and measures of sexual dysfunction, but these were not related to estrogen or androgen levels[19]. In other randomized, clinical trials supplementation of Maca in pre-, peri- and postmenopausal women showed favorable outcomes based on the Kupperman Menopausal index and the Greene Climacteric Score. Furthermore, limited studies have shown evidence for Maca's effect on blood markers. Serum IL-6 levels in a cross-sectional study in 50 subjects were measured with 27 subjects consuming Maca and 23 not consuming Maca. IL-6 was lower in the Maca group and overall there were better health status scores in the SF-20 survey[39].

This study set out to determine the effect of consuming Maca for 6 weeks in Chinese postmenopausal women from Hong Kong. It is clear that there were no differences in weight, BMI, heart rate, estradiol, FSH, SHBG, TSH, HDL cholesterol and LDL cholesterol, triglycerides, plasma cytokines and glucose amongst the Maca and placebo groups; however, there were significant decreases in both systolic and diastolic blood pressures following Maca intake, with diastolic blood pressure being highly significant above baseline and compared to the placebo group. As blood pressure is a risk factor for cardiovascular disease, this could potentially be a significant finding for lowering cardiovascular disease risk. Previous studies had also demonstrated that Maca had no effects on serum estradiol, FSH and TSH levels[9], despite other reports suggesting that Maca elevates luteinizing hormone and reduces FSH following Maca supplemention[6].

Maintaining optimal quality of life is a priority for women just before, during and postmenopause. Measuring quality of life has traditionally been via medicines and biomedical measurements that determine the health status; however, these are not sufficient to accurately determine the overall well-being. Therefore, quality-of-life scales have been developed with the main objectives in mind being psychometric and physical properties. The Greene Climacteric Scale measures psychological, somatic and vasomotor symptoms. The Scale is used to determine changes of symptoms in response to treatment interventions[20,21]. Herein, Maca supplementation in Chinese postmenopausal women was associated with significant reduction in psychological (anxiety and depression) and somatic symptom scores, even though similar changes were observed following placebo supplementation. Maca showed non-significant decreases in sexual dysfunction, vasomotor and urinary scores.

The SF-36 Version 2 health survey assesses functional health (mental and physical) and well-being[22]. The scale determines improvement or decline in health and treatment effectiveness[22–24]. In the current study, following Maca supplementation in Chinese postmenopausal women, subjects showed significant improvement in general and mental health with non-significant improvement in body pain, vitality, social functions and mental component scores. Interestingly, placebo showed similar trends to Maca, with significant improvement in social functioning and mental component scores.

The Women's Health Questionnaire (WHQ), a 36-item questionnaire covering nine areas of physical and mental status, is a well-accepted international questionnaire in assessing postmenopausal symptoms. In Chinese postmenopausal women after Maca supplementation, significant improvements in depression scores and anxiety scores were noted, with non-significant decreases in somatic, memory, vasomotor, sexual dysfunction, mental and attention scores. However, placebo showed significant improvements in somatic, anxiety and sleep scores but not in the depression score. Using the Utian Quality of Life score, there were no statistically significant differences in all four domains of occupational, health, emotional and sexual quality of life. In the recently translated but not validated Chinese Utian Quality of Life questionnaire, varied test reliabilities were demonstrated, of 0.86 (overall), 0.85 (occupational), 0.7 (health-related), 0.66 (emotional) and 0.61 (sexual)[29]. The low reliability scores for emotional and sexual suggest that the reliability for these two domains requires further studies. Hence, the inconsistent result of the Utian Quality of Life score in the current study compared to the GCS, SF-36 Version 2 and WHQ surveys. It is clear from the GCS, SF-36 Version 2 and WHQ surveys that Maca supplements taken by postmenopausal Chinese woman resulted in significant improvements in diastolic blood pressure and depression scores. This is an important outcome given that postmenopausal women are three times more likely to report symptoms of depression compared to premenopausal women. Furthermore, postmenopausal women are more likely to present with cardiovascular disease as compared to men in the same age group. The studies are in accordance with previous studies in males treated with Maca for 12 weeks which lowered depression scores[9], in postmenopausal women treated with Maca showing improved anxiety and depressive scores[19], and that Maca demonstrated antidepressant actions in mice[40]. It is not clear how Maca acts on reducing psychological symptoms, although flavonoids present in Maca may be responsible for these actions[40–43]. Interestingly, the reduced psychological symptoms (depression and anxiety) did not correlate with reduced vasomotor symptoms (hot flushes),

despite a strong association between the two[44,45]. However, estradiol, FSH and TSH levels are associated with vasomotor symptoms, and no changes were noted in these hormones together with no improvement of vasomotor symptoms[46]. However, sleep disorders were significantly improved. Similar findings of no beneficial effects on vasomotor symptoms in Hong Kong Chinese postmenopausal women were reported with the Chinese herb Dang Gui Buxue Tang[47]. In the current study, there was improvement, but not significant, in sexual dysfunction (commonly reported in menopausal women), despite previous studies of Maca supplementation in postmenopausal Australian women[19], in men[9] and in rodents[14]. There are suggestions that women in non-Western countries do not usually report their sexual functions and mental states, but rather freely report somatic symptoms such as headache, back pain and constipation, as opposed to women in Western or developed countries[48–50]. Various studies indicate that differences in symptom reporting are real and that both biological variation and cultural differences contribute to the menopausal transition and that more research is required to elucidate how biology and culture interact in female aging[51,52].

CONCLUSIONS

Overall, we demonstrate that Maca does not exert an estrogenic effect in postmenopausal Hong Kong Chinese women, as indicated by the lack of change in plasma estradiol, FSH, TSH and SHBG concentrations. In addition, Maca has no effect, in immune physiology or other biological markers, in the short term, on body weight, BMI, cholesterol, HDL and LDL cholesterol, triglycerides, glucose and cytokine levels. However, Maca was shown in the small cohort of patients to be effective in reducing blood pressure and depression. Improvements were also noted for psychological, anxiety, somatic, general health, social functioning and mental health in both Maca and placebo groups. These results are comparable to previous similar published studies in postmenopausal women from our and other laboratories. In general, there might be cultural differences amongst the Chinese postmenopausal women in terms of symptom experiencing and reporting, as compared to the Caucasian population. In fact, it has been reported that, although the incidence of hot flushes, for example, among Western women are close to 80%, only 5–10% of Asian women report troublesome vasomotor symptoms[53]. These differences may be due to both cultural and biological variations[51]; however, diet may account for some of the differences. Although there have been a number of observational and randomized, controlled trials conducted for relief of menopausal symptoms, especially vasomotor, the clinical evidence supporting the efficacy and safety of most complementary medicine for relief of menopausal symptoms is sparse. Differences in findings across studies of the same product may be due to less than optimal trial design, variation in products and composition of products used, inadequate dosing, the length of treatment and small population size. Furthermore, any therapy claiming to reduce hot flushes should be assessed in blinded trials as placebo effects are high[54]. The placebo effects in our studies were high, demonstrating the person's anticipation that an intervention will help them, and these effects should be considered in alternative therapies[55]. This study gives strong evidence that a larger study for a longer time is required to further determine the effects of Maca in postmenopausal women.

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