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HOW TO EFFECTIVELY PROTECT THE HUMAN BODY FROM THE HARMFUL INFLUENCE OF XENOESTROGENS AND OTHER ENDOCRINE DISRUPTORS: PREVENTIVE AND THERAPEUTIC PERSPECTIVES

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ABSTRACT

Xenoestrogens constitute a group of endocrine-disrupting chemicals that, by mimicking or interfering with the actions of endogenous estrogens, can affect hormonal balance and reproductive function. Due to their widespread presence in the environment—including plastics, cosmetics, food, and everyday consumer products—complete avoidance of exposure is virtually impossible. However, studies indicate that proper education, lifestyle modifications, and dietary interventions can significantly reduce exposure to these compounds and the associated health risks. This article investigates various strategies for the prevention of xenoestrogen and other endocrine disruptors exposure, the reduction of existing body burdens of these chemicals. The effectiveness of dietary and behavioral interventions is discussed, such as avoiding canned foods and plastic products, as well as using personal care products free from phthalates, parabens, triclosan, and benzophenone-3, all of which have been shown to markedly decrease urinary levels of xenoestrogens and other endocrine disruptors. Therapeutic interventions are also presented, including the use of selected supplements and pharmacological agents such as *Chlorella pyrenoidosa*, cholestyramine, olestra, coenzyme Q10, melatonin, and multi-strain probiotics, which have demonstrated beneficial effects in reducing the concentrations of endocrine-active compounds and mitigating their toxic effects. These findings underscore the critical role of multifaceted approaches, combining preventative behavioral changes with targeted substance interventions, to effectively mitigate exposure and safeguard public health from ubiquitous endocrine-disrupting chemicals (EDCs).

KEYWORDS

Endocrine Disruptors, Environmental Exposure, Risk Reduction Behavior, Diet, Dietary Supplements, Health Education

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Introduction

Xenoestrogens are synthetic or natural chemical compounds that mimic or interfere with the physiological functions of endogenous estrogens. They belong to a broader group of endocrine-disrupting chemicals that can adversely affect hormonal balance, reproductive function, and overall health [1][2]. These compounds are ubiquitous in the modern environment, being found in plastics, food packaging, pesticides, cosmetics, and personal care products [3] [4]. Due to their structural similarity to 17 β -estradiol, xenoestrogens can bind to estrogen receptors and modulate gene expression, thereby influencing the endocrine system at even very low concentrations [1]. Chronic exposure to xenoestrogens and other endocrine disruptors has been associated with numerous adverse health outcomes, including reproductive disorders, early puberty, hormonal cancers, metabolic dysfunctions, and developmental abnormalities [2]. The omnipresence of these compounds in air, water, food, and consumer goods makes complete avoidance virtually impossible. However, scientific evidence suggests that awareness, behavioral modification, and specific dietary or lifestyle interventions can significantly reduce individual exposure levels [3] [4] [2]. Growing research attention has also been directed toward identifying substances that may mitigate or neutralize the toxic effects of endocrine-disrupting chemicals. Various nutritional compounds, antioxidants, and probiotics have demonstrated potential in supporting detoxification mechanisms, reducing oxidative stress, and restoring endocrine balance. These findings underscore the importance of both preventive and therapeutic strategies to counteract the widespread health threats posed by endocrine disruptors [5] [6] [7] [8] [9]. The aim of this paper is to present evidence-based strategies for protecting human health from the harmful effects of xenoestrogens and other endocrine disruptors. The first section focuses on preventive measures that minimize daily exposure through conscious consumer choices, dietary modifications, and behavioral changes [3] [4]. The second section discusses therapeutic and nutritional interventions that may assist in lowering the body's xenoestrogen burden and mitigating their biological impact [5] [6] [10]. Together, these approaches emphasize a comprehensive framework for effective protection against xenoestrogen-induced health risks.

Methodology

This study employed a systematic literature review methodology to examine interventions aimed at reducing human exposure to xenoestrogens and other endocrine disruptors. Sixteen clinical studies, including randomized controlled trials and pilot studies, published between 2006 and 2023 and retrieved from the PubMed database, were subjected to analysis. The review specifically considered interventions based on dietary modifications, changes in cosmetic products and packaging, health education initiatives, and nutritional supplementation. Inclusion criteria for the analysis mandated studies involving human participants that assessed changes in exposure biomarkers, such as endocrine disruptor bisphenol A (BPA), phthalates, parabens, polychlorinated biphenyls (PCBs), or dioxins, both pre- and post-intervention. The selection of publications prioritized currency, availability of complete data, and alignment with the study's thematic focus. The collected data were processed descriptively to facilitate a comparative evaluation of the effectiveness of various strategies for limiting contact with endocrine disruptors and promoting health protection.

Prevention of Xenoestrogen Exposure and other endocrine disruptors

The increasing global reliance on convenient food options, such as fast food, disposable products, and convenient household items, contributes significantly to exposure to endocrine-disrupting chemicals, with bisphenol A being a prominent example. Notably, dietary intake accounts for over 90% of total chemical exposure, and specifically, 72.5% of BPA exposure in most individuals. This phenomenon renders young adults particularly vulnerable to BPA exposure due to their high-convenience lifestyles and frequent consumption of processed foods and disposable items. One of the studies aimed to investigate the effects of a dietary modification intervention on menstrual pain and urinary BPA levels in female college students. Thirty female students, enrolled in their second or third year of study and reporting menstrual pain scores of 5 or higher on a 10-point scale. The intervention comprised three key components: small-group education, weekly follow-up monitoring, and peer support facilitated through social media communication. The educational component informed participants about the harmful effects of EDCs and strategies to reduce exposure, including specific details on BPA and its sources, particularly plastics. Follow-up monitoring involved participants submitting weekly checklists to assess adherence to dietary modifications, complemented by supportive feedback from a research assistant. Peer support aimed to foster shared experiences and emotional reinforcement within small groups. Urinary BPA levels were measured four times: at baseline and after each of the three subsequent menstrual cycles, with menstrual pain also being evaluated at these time points using a 10-point scale. The intervention yielded significant reductions in both urinary BPA levels and menstrual pain. Specifically, urinary BPA levels significantly decreased until the second menstrual cycle post-intervention, while menstrual pain was significantly alleviated across all three post-intervention cycles. The study further categorized participants based on their adherence to the dietary modifications, revealing that 43.3% demonstrated high adherence. This high-adherence group exhibited more favorable outcomes, including a greater reduction in menstrual pain, compared to those with low adherence, who effectively served as a control group. This highlights that a dietary modification intervention can be an effective and sustainable strategy for reducing menstrual pain and urinary BPA levels. The findings suggest that detailed information about EDCs and guidance on dietary experiences can motivate young women to adopt self-protective behaviors, emphasizing the importance of targeted interventions and ongoing education [11].

Diet is a primary source of phthalates, which are known endocrine-disrupting chemicals. Phthalates, commonly used as plasticizers, are ubiquitous in various consumer goods, ranging from personal care products to vinyl flooring and medical devices, and are frequently found in food due to migration from packaging materials. Consequently, dietary intake represents a significant route of human exposure to these compounds. Barrett and colleagues conducted a study to investigate the effectiveness of a dietary intervention in reducing phthalate exposure among pregnant women. Eligible participants were in their seventh month of single gestation or less, had a household income below \$25,000, reported no major dietary restrictions or allergies, and had no significant pregnancy complications. The study spanned seven days, beginning with baseline phthalate measurements. Participants then followed a low-phthalate diet for two to four days, during which additional samples were collected. On day five, participants resumed their usual diet, and a final urine sample was collected on day seven to assess phthalate levels. Throughout the study, participants maintained detailed food diaries, documenting all consumed foods and beverages. Despite the structured intervention, five out of ten participants reported non-adherence to the low-phthalate diet. Critically, the study did not observe a significant reduction in urinary phthalate concentrations. These findings suggest that limiting phthalates in food processing and packaging may be a more effective strategy for reducing population-level exposure

compared to individual dietary modifications. This highlights the challenges of behavioral interventions and underscores the need for broader public health and regulatory measures to mitigate phthalate exposure [12]. Randomized trial investigated the effectiveness of two distinct interventions. In the first group, participants were instructed to consume exclusively catered meals during a 5-day intervention period. These catered meals were meticulously designed to be fresh, locally sourced, and organic whenever feasible. Furthermore, their preparation, storage, and transportation were conducted without the use of plastics. For example, the catering company explicitly requested fresh produce deliveries in wooden crates rather than plastic cartons to mitigate potential contamination. Additionally, families were advised to use filtered water and consume beverages from non-plastic containers. In the second group, participants received educational materials in the form of handouts during their initial study visit. These materials, developed by national Pediatric Environmental Health Specialty Units, provided comprehensive information. This included descriptions of phthalates and BPA, identification of exposure sources with a particular emphasis on plastic products, and recommendations for reducing daily exposures. The objective of this intervention was to empower participants with sufficient time and knowledge to independently plan, purchase, and prepare food in accordance with these written guidelines. Participants in both groups were supplied with glass food storage containers and encouraged to utilize non-plastic utensils and dishware. Unexpectedly, neither intervention effectively reduced exposure to the targeted compounds. In the dietary replacement group, despite rigorous efforts to provide fresh, organic, and plastic-free foods, a significant increase in the concentrations of certain phthalate metabolites (e.g., DEHP) and BPA was observed. This unforeseen rise was attributed to inherent contamination within the food supply itself. The group receiving written recommendations similarly demonstrated no decrease in biomarker concentrations, a result potentially influenced by barriers to adherence or insufficient specificity in the provided guidance. The study concluded that current intervention methodologies are inadequate for consistently lowering phthalate and BPA exposures, thereby emphasizing the need for enhanced public education and potentially broader regulatory actions to address food contamination [1]. Another study investigated the impact of a fresh-food intervention on reducing exposure to bisphenols and phthalates. The study recruited 20 participants, comprising 10 adults (median age 40.5 years) and 10 children (median age 7 years) from five families, all of whom reported high consumption of canned foods. The study design involved three phases: an initial period of usual diet, followed by a three-day intervention period of consuming "fresh food," and then a return to their habitual diet. During the intervention, participants consumed food prepared almost exclusively from fresh and organic fruits, vegetables, grains, and meats. Food preparation methods avoided contact with plastic utensils and non-stick cookware, and food was stored in glass containers with BPA-free plastic lids, ensuring food did not touch the lids. Families were instructed to use only these designated containers for storage and to avoid microwaving the lids. Additionally, participants were provided with stainless steel water bottles and lunch containers to minimize exposure from other common sources of bisphenol A and phthalates. While encouraged to consume only provided food, participants were advised that if necessary, they could supplement with fresh produce, eggs, peanut butter, and jelly from glass jars, as well as milk and orange juice from glass or low-density polyethylene plastic containers if glass was unavailable. Coffee drinkers were recommended to use a French press or ceramic pour-over instead of plastic coffee makers or coffee shop purchases. Urinary concentrations of BPA and diethylhexyl phthalate metabolites were measured at each stage. A significant reduction in the urinary concentrations of BPA and DEHP metabolites was observed during the fresh food intervention. Maximum values were reduced by 76% for BPA and between 93% and 96% for DEHP metabolites. These findings suggest that limiting the use of phthalates in food processing and packaging could be a more effective approach to reduce population-level exposure. Upon participants returning to their usual diet, BPA levels increased to approximately pre-intervention levels. No significant differences were found in urinary BPA concentrations between adults and children; however, adults exhibited significantly higher concentrations of monoethyl phthalate compared to children.

Potential sources of exposure noted two days before and three days after the intervention included meals prepared outside the home, canned foods, canned beverages, frozen foods, consumption of water from polycarbonate bottles, and microwaving plastics. All families reported consuming canned foods or at least one meal away from home in the pre- or post-intervention phases. Two families indicated microwaving frozen foods in plastic, and seven out of ten adults and five out of ten children drank canned beverages. These observations highlight the widespread environmental presence of these chemicals and the effectiveness of a targeted dietary intervention in reducing acute exposure [13].

Women are primary consumers of cosmetics, with the average adult women using 12 personal care products and teenagers using 17 (e.g., shampoos, deodorants, perfumes, nail polishes, creams, lotions).

Consequently, women are more susceptible to exposure to harmful substances contained within these products. A study involving 100 adolescent Latina girls who used cosmetics containing phthalates, parabens, triclosan, and benzophenone-3 investigated this exposure. Participants were instructed to cease using their regular cosmetics for three days and instead utilize products devoid of these substances. They were also asked to avoid using any personal hygiene or cosmetic products not supplied by the study; if a specific product type was not provided, participants were asked to abstain from using it during the intervention period. Subsequent urine analysis revealed a significant reduction in the concentration of monoethyl phthalate by an average of 27.4%. Methyl and propyl paraben concentrations decreased by 43.9% and 45.4%, respectively. Unexpectedly, ethyl and butyl paraben concentrations increased, although their overall levels were low and undetectable in nearly half of the samples. Triclosan concentration decreased by 35.7%, and BP-3 concentration decreased by 36.0%. This study unequivocally demonstrates that the conscious selection of cosmetics free from endocrine-disrupting chemicals substantially mitigates exposure to the detrimental effects of these substances [14].

Scientists conducted a study to investigate the effects of reducing exposure to xenoestrogens contained in personal care products (PCPs). The study recruited women with regular menstrual cycles who were regular users of PCPs and had no prior cancer diagnosis. Exclusion criteria encompassed pregnancy, lactation, breast augmentation, renal disease, and cardiac conditions. Participants were randomly assigned to either the REDUXE intervention group and control group.

The intervention group, comprising 41 individuals, followed a specific protocol and utilized a kit of parabene- and phthalate-free personal care products for a 28-day period. Post-intervention urinary analysis revealed a significant reduction in the concentrations of all tested parabens—methylparaben, ethylparaben, propylparaben, and butylparaben—as well as the diethyl phthalate metabolite, monoethyl phthalate. Additionally, blood concentrations of parabens and phthalates were also reduced. In contrast to the observed reduction in urinary xenoestrogen levels, serum concentrations of estrogen (E2), progesterone, and sex hormone-binding globulin in matched samples remained relatively stable.

Breast tissue biopsies performed after the study revealed that the *in vivo* changes resulting from the use of xenoestrogen-free product kits represented beneficial shifts that counteracted pre-existing pro-carcinogenic profiles. Notably, in the intervention group, transcript levels of 80% of putative oncogenes were downregulated, while transcript levels of 60% of putative tumor suppressor genes were upregulated when compared to the control group. Maintaining a REDUXE-based approach to personal care product plausible preventive strategy [2].

Todd Hagobian and colleagues conducted a randomized interventional study involving 24 healthy, normal-weight women, non-smoking women without chronic diseases who were exposed to Bisphenol A found in hygiene products such as soap, shampoo, tampons, sanitary pads, and cosmetics. At the study's outset and following a three-week intervention period, fasting urinary BPA and creatinine concentrations, along with body weight, were measured. The control group received weekly newsletters containing general information about bisphenols and their health impacts. Conversely, participants in the intervention group attended weekly counseling sessions, where they were educated on BPA's detrimental health effects and strategies for exposure mitigation, including dietary adjustments, prioritizing organic products, and adopting manufacturer-recommended BPA-free personal hygiene items. Daily plastic products containing BPA were replaced with non-BPA alternatives, such as glass and cardboard. Participants were also required to maintain a log of consumed products and their packaging. This three-week behavioral intervention significantly reduced urinary BPA concentrations in the intervention cohort compared to the control group. Specifically, the geometric mean urinary BPA concentration decreased by 0.71 ng/mL in the intervention group, whereas it increased by 0.32 ng/mL in the control group, thereby demonstrating the intervention's short-term effectiveness in lowering urinary BPA levels among normal-weight college-aged women [3]. Building on these findings, Hagobian and his team further explored in 2021 whether a comparable intervention could diminish bisphenol exposure in obese women, a demographic particularly susceptible to the adverse effects of bisphenols, often exhibiting higher exposure levels than normal-weight women and men. This follow-up study enrolled 30 obese women, randomized to either a three-week intervention or control group. Consistent with the prior study, fasting urinary bisphenol levels, creatinine, and body weight were assessed at baseline and after three weeks. Participants in both groups received the identical intervention protocol administered to the normal-weight women. A secondary analysis indicated that the three-week behavioral intervention successfully reduced bisphenol S exposure in obese women relative to the control group. The geometric mean concentration of creatinine-adjusted bisphenol S (BPS) in urine decreased by 1.42 µg/g in the intervention group, while showing only a marginal decrease of 0.09 µg/g in the control group. Collectively, these two investigations substantiate the

short-term effectiveness of a social-cognitive theory-based intervention in reducing urinary bisphenol concentrations across both normal-weight and obese female populations [15].

Ju Hee Kim and associates undertook a randomized controlled trial involving 51 women to ascertain the effectiveness of a behavioral intervention designed to reduce the exposure of mothers with young children to endocrine disruptors. The study allocated 26 participants to an intervention group, which was provided with an online educational program featuring an educational film, an interactive game for identifying household endocrine disruptors, and a question-and-answer segment. This group was also prompted to implement changes in their dietary and health practices. The remaining 25 women formed the control group, receiving informational brochures about endocrine disruptors via postal service. Participants from both cohorts submitted samples for the quantification of six key endocrine disruptors: mono (2-ethylhexyl) phthalate (MEHP), mono (2-ethyl-5-oxohexyl) phthalate (MEOHP), bisphenol A (BPA), methylparaben (MP), ethylparaben (EP), and propylparaben (PP). Urinary concentrations of these metabolites were assessed at three distinct time points: at the study's commencement, after the initial week of intervention, and at the conclusion of the one-month intervention and reinforcement phase. Subsequent to one month of intervention, a statistically significant reduction in the geometric mean concentrations of MEHP, MEOHP, BPA, MP, EP, and PP was observed within the intervention group when compared to the control group. These observed declines ranged from 3.8% to 28.4% relative [4].

Therapeutic Interventions to Reduce Xenoestrogen Burden and Other Endocrine Disruptors

Chlorella

The omnipresent environmental contamination is evidenced by the detection of dioxins in human breast milk, raising concerns regarding potential disorders in nursing infants. Research on 35 pregnant Japanese women aimed to investigate this issue, particularly given that animal studies have established the adverse effects of dioxins on postnatal cognitive and behavioral functions following transplacental and lactational exposure. To explore potential interventions, a clinical trial examined the impact of *Chlorella pyrenoidosa* supplementation on dioxin concentrations in breast milk. Eighteen women in the intervention group received *Chlorella* supplements during their pregnancy. Postpartum, breast milk samples were collected from all subjects between 3 and 9 days after delivery. These samples were subsequently analyzed for various congeners, including six polychlorinated dibenzo-p-dioxins, ten polychlorinated dibenzofurans, and twelve coplanar polychlorinated biphenyls (co-PCB). The findings indicated that total toxic equivalents of dioxins were significantly lower in the breast milk of women who received *Chlorella* supplementation compared to the control group ($P \leq .003$). These results suggest that maternal *Chlorella* supplementation could effectively reduce the transfer of dioxins to infants via breast milk. Furthermore, the study observed a significant elevation in immunoglobulin A concentrations in the breast milk of the *Chlorella* group ($P \leq .03$). This increase in IgA is considered beneficial for enhancing biodefense and reducing the risk of infection in nursing infants [5].

Coenzyme Q10

A study utilizing *Caenorhabditis elegans* as a model organism investigated the adverse reproductive effects of bisphenol A, a pervasive plasticizer and endocrine-disrupting chemical, and evaluated the potential ameliorative capacity of coenzyme Q10. In the experimental setup, *C. elegans* strains were exposed to BPA and dimethyl sulfoxide in the culture medium to achieve a final dimethylsulfoxide (DMSO) concentration of 0.1%. This was followed by the administration of CoQ10 at concentrations of 5, 30, and 100 µg/ml for 24 hours, commencing at the late L4 larval stage. This specific developmental timing was chosen because the germline is fully formed, and all meiotic nuclei are undergoing oogenesis. This exposure protocol was designed to approximate the chronic, lifelong exposure to such compounds experienced by humans and to assess the potential utility of CoQ10 as an intervention during human pre-conception or pregnancy. Exposure to BPA, particularly at the highest tested concentration of 500 µM, resulted in a statistically significant increase in embryonic mortality, larval mortality, and a reduction in brood size. These findings underscore the reprotoxic potential of BPA, consistent with previous research indicating that BPA impairs mammalian reproductive health, leading to decreased sperm and oocyte quality, increased embryonic lethality, and higher miscarriage rates in humans. Crucially, supplementation with CoQ10 significantly attenuated these adverse reproductive consequences induced by BPA exposure. Specifically, CoQ10 effectively prevented the BPA-induced decrease in brood size and reduced both embryonic and larval mortality. This suggests a beneficial role for CoQ10 in safeguarding the *C. elegans* germline from the detrimental effects of BPA.

The study concludes that antioxidant supplementation with CoQ10 effectively mitigates BPA-induced reprotoxicity in *Caenorhabditis elegans*. This protective action is attributed, at least in part, to CoQ10's ability to combat oxidative stress-induced DNA damage. Given its natural antioxidant properties, CoQ10 could represent a low-risk and economically viable strategy for ameliorating the detrimental impact of BPA on fertility. The researchers posit that CoQ10 exerts its protective effects primarily by neutralizing oxidative DNA damage. BPA exposure leads to increased meiotic double-strand breaks and oxidative stress within the germline, which CoQ10 can rescue. CoQ10 significantly reduced BPA-induced elevated levels of germ cell apoptosis, phosphorylated checkpoint kinase 1, double-strand breaks, and chromosomal defects in diakinesis oocytes. It also counteracted BPA-induced oxidative stress, mitochondrial dysfunction, and the increased expression of antioxidant enzymes in the germline. These findings indicate that CoQ10 acts by scavenging reactive oxygen species and free radicals [8].

Probiotic

A study was conducted to investigate the efficacy of a multi-strain probiotic in ameliorating the toxic effects of bisphenol A and phthalates in Wistar rats. The experimental design involved four groups: a control group administered corn oil; a probiotic (P) group receiving the commercial multi-strain probiotic preparation Enterobiotik® FORTE, which included 8.5×10^9 lyophilized cells including *Saccharomyces boulardii*, *Lactobacillus rhamnosus*, and two strains of *Lactobacillus plantarum*; a mixture group (MIX) exposed to a blend of di-(2-ethylhexyl) phthalate at 50 mg/kg body weight/day, dibutyl phthalate at 50 mg/kg body weight/day, and BPA at 25 mg/kg body weight/day; and a mixture + probiotic (MIX + P) group that received both the toxic mixture and the probiotic. After 28 days of exposure, the animals were euthanized, and tissues were collected for subsequent analysis.

The results indicated a significant ameliorative effect of the multi-strain probiotic against the toxic mixture across various physiological parameters, with the most favorable outcomes consistently observed in the MIX + P group. Regarding body weight dynamics, while all treated groups exhibited a decrease in body weight gain after the third week, this reduction was most pronounced in the MIX group (approximately -20%), whereas the MIX + P group experienced a less significant decrease (approximately -15%). The substantial weight loss in the MIX group persisted into the fourth week, demonstrating that probiotic supplementation effectively mitigated this severe reduction in body weight gain in the MIX + P group. Furthermore, total food intake was significantly lower in the MIX group compared to the rest groups, with probiotic administration in the MIX + P group effectively attenuating the negative impact of the toxic mixture on food consumption. Similarly, water consumption, although lowest in the MIX group, showed a less marked reduction in the MIX + P group. In terms of hormonal regulation, exposure to the toxic mixture in the MIX group led to a significant increase in serum thyroxine (T4) levels and a concurrent decrease in both the triiodothyronine/thyroxine (T3/T4) ratio and serum testosterone levels. Notably, probiotic treatment in the MIX + P group successfully attenuated all these detrimental hormonal alterations, thereby demonstrating a protective role. Beyond these, the multi-strain probiotic exhibited protective effects against liver and kidney toxicity, unfavorable alterations in lipid status, serum glucose levels, and systemic inflammation induced by the toxic mixture. In conclusion, the study provides compelling evidence that a multi-strain probiotic can effectively counteract a broad spectrum of toxicological endpoints caused by a mixture of phthalates and BPA in Wistar rats, with the MIX + P group consistently exhibiting superior outcomes across multiple parameters [9].

Colestimide

To explore the potential of colestimide, a cholesterol-lowering medication, in mitigating accumulated dioxin levels, Kenichi Sakurai and colleagues conducted a pilot study. The investigation enrolled eight men and two women, all diagnosed with hyperlipoproteinemia, who received a daily dosage of 3 g/day of colestimide for a six-month period. Blood samples were collected and analyzed for dioxin concentrations both prior to and following the treatment phase. The findings from nine participants who completed the study indicated an average reduction of 20% in dioxin levels. Specifically, the mean dioxin concentration decreased from an initial 44.0 ± 8.22 pg-TEQ/g-fat to 34.7 ± 5.49 pg-TEQ/g-fat post-treatment [16]. Following the promising results of a pilot investigation that established colestimide effectiveness in decreasing human blood dioxin concentrations, Kenichi Sakurai and collaborators expanded their research efforts. This subsequent study aimed to quantify polychlorinated biphenyl (PCB) levels in blood samples and determine if a six-month colestimide regimen could equivalently reduce PCB concentrations. The extended administration of colestimide for six months resulted in a decrease in the mean PCB level among the participants, declining from 0.26 ± 0.16 µg/g-fat at baseline to 0.20 ± 0.11 µg/g-fat post-treatment. Furthermore, a statistically significant correlation was observed between the reduction factor for blood PCB concentration and that for blood dioxin levels subsequent to colestimide therapy ($R = 0.91$) [6]. These findings suggest that colestimide possesses the

potential to lower both dioxin and PCB levels in human blood. Nevertheless, the researchers emphasize the critical need for a large-scale, randomized controlled trial to robustly corroborate these encouraging preliminary findings [6, 16].

Olestra

Researchers based in Cincinnati, Ohio, conducted a randomized study to evaluate whether the daily addition of 15g/day of the non-absorbable fat, olestra, to the diet could reduce an individual's systemic burden of (PCBs) and 1,1-bis-(4-chlorophenyl)-2,2-dichloroethene (DDE), compared to a placebo. The study enrolled residents of Anniston, Alabama, who exhibited serum PCB levels exceeding the 50th percentile nationally. Participants were randomly assigned into two groups, each comprising 14 individuals: an intervention group and a control group. The intervention group consumed potato chips prepared with olestra (a non-absorbable lipid), while the control group received chips made with conventional vegetable oil. PCB and DDE concentrations were quantified at baseline and at four-month intervals throughout the 12-month study duration. Over the course of the study, PCB concentrations in the vegetable oil control group declined to 96% of their baseline values, which was consistent with the annual 97% decrease predicted by pre-study measurements. Conversely, in the olestra intervention group, PCB concentrations decreased to 92% of baseline after 12 months of dietary intervention, compared to a predicted decline to 99%. The observed reduction in PCB levels within the olestra group during the study period was significantly greater than predicted by pre-study measurements. These findings substantiate the hypothesis that olestra facilitates an accelerated rate of PCB elimination from the human body [10].

Melatonin

Melatonin, a hormone primarily associated with the regulation of circadian rhythms, has become a subject of research regarding its capacity to mitigate the detrimental effects of xenoestrogens. Current findings indicate that melatonin is produced not only by the pineal gland but also by various reproductive cells, including granulosa cells. A recent study investigated this phenomenon using human ovarian granulosa cells (GCs), which were isolated from three distinct donors undergoing in vitro fertilization after controlled ovarian stimulation. Donor recruitment criteria specified ages between 32 and 38 years, while excluding individuals with endometriosis and polycystic ovary syndrome. Connexin 43 (Cx43) is of particular significance among connexins due to its involvement in every stage of folliculogenesis, with its expression progressively increasing during follicular development and oocyte maturation. Furthermore, follicle-stimulating hormone (FSH) is known to enhance the expression of connexin 43 through FSH receptor (FSHR) in GCs. The study revealed that GCs exposed to bisphenol A exhibited minimal expression of the follicle-stimulating hormone receptor. Conversely, GCs treated concurrently with BPA and melatonin demonstrated robust FSHR expression, indicating that melatonin can reverse the BPA-induced downregulation of FSHR expression in GCs. Melatonin successfully restored this FSH-induced Cx43 expression in BPA-treated GCs. Moreover, melatonin effectively restored the proportion of FSH-increased FSHR⁺Cx43⁺ cell populations in BPA-treated GCs, with a significantly higher proportion observed in GCs cotreated with BPA and melatonin (21.3%) compared to those treated with BPA alone (8.6%) before FSH addition. This restoration within the ovarian microenvironment can significantly influence the toxic effects of BPA and bolster the protective efficacy of melatonin. These findings highlight the therapeutic potential of melatonin in combating BPA-induced reproductive toxicity [7].

Conclusions

This research highlights the efficacy of various interventions, including dietary modifications and the use of xenoestrogen-free personal care products, in reducing exposure to endocrine-disrupting chemicals like BPA, phthalates, and parabens. Specifically, dietary changes demonstrated significant reductions in both urinary BPA levels and associated menstrual pain. Furthermore, specific substances like *Chlorella pyrenoidosa* and Olestra demonstrate therapeutic potential by actively reducing the body burden of persistent organic pollutants such as dioxins and PCBs. These findings underscore the importance of both conscious consumer choices and the exploration of dietary supplements as strategies to mitigate xenoestrogen and other endocrine disruptors. Ultimately, a multifaceted approach combining preventative behaviors with specific substance interventions is crucial for safeguarding against the pervasive environmental presence of these endocrine-disrupting chemicals. However, challenges remain, as some interventions encountered limitations due to inherent food supply contamination and participant adherence issues, hindering consistent reduction in biomarker concentrations.

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1. Sathyanarayana, S., Alcedo, G., Saelens, B. E., Zhou, C., Dills, R. L., Yu, J., & Lanphear, B. (2013). Unexpected results in a randomized dietary trial to reduce phthalate and bisphenol A exposures. *Journal of Exposure Science & Environmental Epidemiology*, 23(4), 378–384. <https://doi.org/10.1038/jes.2013.9>
2. Dairkee, S. H., Moore, D. H., Luciani, M. G., Anderle, N., Gerona, R., Ky, K., Torres, S. M., Marshall, P. V., & Goodson III, W. H. (2023). Reduction of daily-use parabens and phthalates reverses accumulation of cancer-associated phenotypes within disease-free breast tissue of study subjects. *Chemosphere*, 322, Article 138014. <https://doi.org/10.1016/j.chemosphere.2023.138014>
3. Hagobian, T., Smouse, A., Streeter, M., Wurst, C., Schaffner, A., & Phelan, S. (2017). Randomized intervention trial to decrease bisphenol A urine concentrations in women: Pilot study. *Journal of Women's Health*, 26(2), 128–132. <https://doi.org/10.1089/jwh.2016.5746>
4. Kim, J. H., Kwak, J. M., & Kang, H. (2021). Web-based behavioral intervention to reduce exposure to phthalate metabolites, bisphenol A, triclosan, and parabens in mothers with young children: A randomized controlled trial. *International Journal of Hygiene and Environmental Health*, 236, Article 113798. <https://doi.org/10.1016/j.ijheh.2021.113798>
5. Nakano, S., Takekoshi, H., & Nakano, M. (2007). Chlorella (*Chlorella pyrenoidosa*) supplementation decreases dioxin and increases immunoglobulin A concentrations in breast milk. *Journal of Medicinal Food*, 10(1), 134–142. <https://doi.org/10.1089/jmf.2006.023>
6. Sakurai, K., Fukata, H., Todaka, E., Saito, Y., Bujo, H., & Mori, C. (2006). Colestimide reduces blood polychlorinated biphenyl (PCB) levels. *Internal Medicine*, 45(5), 327–328. <https://doi.org/10.2169/internalmedicine.45.1478>
7. Lin, T.-C., Wang, K.-H., Chuang, K.-H., Kao, A.-P., & Kuo, T.-C. (2025). Melatonin reverses bisphenol A-induced toxicity in granulosa cells: Restoration of FSHR and connexin 43 expression. *Taiwanese Journal of Obstetrics & Gynecology*, 64(3), 469–476. <https://doi.org/10.1016/j.tjog.2025.02.003>
8. Hornos Carneiro, M. F., Shin, N., Karthikraj, R., Barbosa, F., Kannan, K., & Colaiácovo, M. P. (2020). Antioxidant CoQ10 restores fertility by rescuing bisphenol A-induced oxidative DNA damage in the *Caenorhabditis elegans* germline. *Genetics*, 214(2), 381–395. <https://doi.org/10.1534/genetics.119.302939>
9. Baralić, K., Živančević, K., Javorac, D., Buha Djordjevic, A., Anđelković, M., Jorgovanović, D., Antonijević Miljaković, E., Čurčić, M., Bulat, Z., Antonijević, B., & Đukić-Ćosić, D. (2020). Multi-strain probiotic ameliorated toxic effects of phthalates and bisphenol A mixture in Wistar rats. *Food and Chemical Toxicology*, 143, Article 111540. <https://doi.org/10.1016/j.fct.2020.111540>

10. Jandacek, R. J., Heubi, J. E., Buckley, D. D., Khoury, J. C., Turner, W. E., Sjödin, A., Olson, J. R., Shelton, C., Helms, K., Bailey, T. D., Carter, S., Tso, P., & Pavuk, M. (2014). Reduction of the body burden of PCBs and DDE by dietary intervention in a randomized trial. *The Journal of Nutritional Biochemistry*, 25(4), 483–488. <https://doi.org/10.1016/j.jnutbio.2014.01.002>
11. Park, S., & Chung, C. (2021). Effects of a dietary modification intervention on menstrual pain and urinary BPA levels: A single-group clinical trial. *BMC Women's Health*, 21, Article 58. <https://doi.org/10.1186/s12905-021-01199-3>
12. Barrett, E. S., Velez, M., Qiu, X., & Chen, S.-R. (2015). Reducing prenatal phthalate exposure through maternal dietary changes: Results from a pilot study. *Maternal and Child Health Journal*, 19(9), 1936–1942. <https://doi.org/10.1007/s10995-015-1707-0>
13. Rudel, R. A., Gray, J. M., Engel, C. L., Rawsthorne, T. W., Dodson, R. E., Ackerman, J. M., Rizzo, J., Nudelman, J. L., & Brody, J. G. (2011). Food packaging and bisphenol A and bis(2-ethylhexyl) phthalate exposure: Findings from a dietary intervention. *Environmental Health Perspectives*, 119(7), 914–920. <https://doi.org/10.1289/ehp.1003170>
14. Harley, K. G., Kogut, K., Madrigal, D. S., Cardenas, M., Vera, I. A., Meza-Alfaro, G., She, J., Gavin, Q., Zahedi, R., Bradman, A., Eskenazi, B., & Parra, K. L. (2016). Reducing phthalate, paraben, and phenol exposure from personal care products in adolescent girls: Findings from the HERMOSA intervention study. *Environmental Health Perspectives*, 124(10), 1600–1607. <https://doi.org/10.1289/ehp.1510514>
15. Hagobian, T., Delli-Bovi, Z., Mercado, A., Bird, A., Guy, M., & Phelan, S. (2021). Development and feasibility of randomized trial to reduce urinary bisphenols in women with obesity. *Pilot and Feasibility Studies*, 7, Article 24. <https://doi.org/10.1186/s40814-020-00744-5>
16. Sakurai, K., Todaka, E., Saito, Y., & Mori, C. (2004). Pilot study to reduce dioxins in the human body. *Internal Medicine*, 43(9), 792–795. <https://doi.org/10.2169/internalmedicine.43.792>