A systematic review of internet-based worksite wellness approaches for cardiovascular disease risk management: outcomes, challenges & opportunities

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Citation
A Systematic Review of Internet-Based Worksite Wellness Approaches for Cardiovascular Disease Risk Management: Outcomes, Challenges & Opportunities

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Abstract

Context: The internet is gaining popularity as a means of delivering employee-based cardiovascular (CV) wellness interventions though little is known about the cardiovascular health outcomes of these programs. In this review, we examined the effectiveness of internet-based employee cardiovascular wellness and prevention programs.

Evidence Acquisition: We conducted a systematic review by searching PubMed, Web of Science and Cochrane library for all published studies on internet-based programs aimed at improving CV health among employees up to November 2012. We grouped the outcomes according to the American Heart Association (AHA) indicators of cardiovascular wellbeing – weight, BP, lipids, smoking, physical activity, diet, and blood glucose.

Evidence Synthesis: A total of 18 randomized trials and 11 follow-up studies met our inclusion/exclusion criteria. Follow-up duration ranged from 6 – 24 months. There were significant differences in intervention types and number of components in each intervention. Modest improvements were observed in more than half of the studies with weight related outcomes while no improvement was seen in virtually all the studies with physical activity outcome. In general, internet-based programs were more successful if the interventions also included some physical contact and environmental modification, and if they were targeted at specific disease entities such as hypertension. Only a few of the studies were conducted in persons at-risk for CVD, none in blue-collar workers or low-income earners.

Conclusion: Internet based programs hold promise for improving the cardiovascular wellness among employees however much work is required to fully understand its utility and long term impact especially in special/at-risk populations.

Introduction

Despite advances in cardiovascular disease (CVD) prevention in the United States (US), CVD continues to be a major public health problem with the 2008 mortality data showing CVD accounting for 2,000 deaths per day [1]. The continuing burden of CVD in the US is largely driven by the high prevalence of major cardiovascular disease risk factors such as obesity, hypertension, diabetes, and cigarette smoking[1]. Therefore, CV health promotion in the US has witnessed a shift towards trying to improve CV health by reducing its risk factors [2]. The 2020 goals identified by the American Heart Association (AHA) put reduction of CVD mortality on par with improving CV health for all Americans[2]. The AHA’s strategy of improving CV health rests on tackling seven major CVD determinants, namely blood pressure, physical activity (PA), total cholesterol (TC), healthy diet, healthy weight, non-smoking and blood glucose[1]. Based on 2007–2008 NHANES data, only 16% of US adults [about 12% of men] had the ideal for 5 or more of these metrics [1].

With about 59% of the entire US population currently in the workforce, CVD prevention through worksite wellness programs provide an opportunity to reach many Americans that would have been hard to recruit otherwise. As such, the AHA has emphasized worksite-based CVD prevention, and the need for effective interventions to improve CV health among the working population [3]. On the other hand, the widespread availability and use of
the internet has provided a unique and efficient avenue to engage an increasing number of people in health-related programs [4]. This is particularly relevant to remote workers and those with non-conventional schedules. As a result, employers are beginning to incorporate web-based approaches into their wellness programs.

The expansion of worksite-based wellness programs and use of the internet as delivery means, carries with it the need to sort out the evidence about their effectiveness. In the last two decades, the effectiveness of several internet-based CV wellness programs among employees have been studied with significant variance in the interventions, study design, duration and outcomes. Reviews of available evidence from such programs have been published [5–10], yet none has focused on internet-based CV wellness among workers.

In this systematic review we aim to synthesize the available evidence from internet-based CV wellness programs in order to guide the implementation and future development of such programs.

Methods

We conducted a systematic review by searching PubMed, Web of Science and Cochrane library for all published studies on internet-based programs aimed at improving CV health among employees or workers up to November 2012. Using the advanced search feature we combined MESH terms and text word (tw) terms (MEDLINE or Cochrane) such as internet, web-based, online; worker, employee, workplace, worksite; and occupational health, health promotion, and wellness programs; and hypertension, blood pressure, dyslipidemia, smoking, body mass index. Table 1 outlines the search strategy in PubMed.

In Web of Science we conducted our search employing similar search terms using the topic feature (TS). We also searched the bibliographies of the articles we found for relevant studies. We included only studies conducted in employee/working populations, whose interventions required accessing the internet and who reported CV measures of effect on employees that participated in these interventions. The CV outcomes were weight and weight related (including waist circumference, body mass index (BMI), skin fold thickness and body fat), physical activity measures, lipids [including any of total cholesterol, low density lipoprotein cholesterol (LDL-c), high lipoprotein cholesterol (HDL-c) and triglycerides], dietary changes, blood pressure, smoking cessation and blood glucose/HbA1c. We excluded case series, case reports, systematic or general reviews, studies with less than 6 months follow-up duration, and studies conducted in non-employee populations. We defined internet-based studies as those requiring study participants to log-on to the internet as part of the intervention. This included web site use and/or email access.

The database search was conducted by one reviewer (ECA) and the inclusion/exclusion criteria were applied by two independent reviewers (ECA, LLR). Only those studies that were agreed upon by both reviewers to meet the specified criteria were included in the final qualitative analysis. There was no formal protocol for this systematic review.

Methodological criteria as designed by Ogilvie et al. [11] (see appendix 1) were applied to the studies. This assessment has 2 components – suitability of study design and methodological quality criteria. Each study was assessed for both components. High quality studies were those that had grade A or B for study design and at least 4 of 6 methodological criteria. No studies were excluded due to poor quality.

Results

As shown in figure 1, we included twenty-nine (29) studies in our review, 18 of which were randomized studies while the others employed pre-post design with no comparison groups. Follow-up duration was between 6 months and 2 years. We found all the randomized studies to be of high-quality. Among the non-randomized studies only one was of intermediate quality, having a comparison group and 3 of the 6 methodological quality criteria [12]. The other non-randomized studies were of low-quality. The details of the individual methodological quality scoring can be found in appendix 2.

Description of Interventions

In general, the interventions could be grouped into largely internet-based programs with minimal interaction with the environment or study personnel (referred to as largely internet-based through out this section), or multi-component interventions in which non-internet features played more than a minor role. Among the randomized studies, 16 were largely internet-based[13–28], while the other 2 were multi-component studies[29,30]. Similarly, 2 of the 10 interventions (11 studies) in the pre-post group had multiple components[31,32], while the others were largely internet-based [12,33–40]. Summary of the studies included in the review categorized according to the two main designs used can be found in tables 2 and 3.

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**Table 1. PubMed Search Strategy.**

<table>
<thead>
<tr>
<th>Search number</th>
<th>Search terms/Combinations</th>
<th>Number of Items found</th>
</tr>
</thead>
<tbody>
<tr>
<td>#9</td>
<td>#5 AND #6 AND #7 AND #8</td>
<td>32</td>
</tr>
<tr>
<td>#8</td>
<td>#3 AND #4</td>
<td>57172</td>
</tr>
<tr>
<td>#7</td>
<td>#1 AND #2</td>
<td>87124</td>
</tr>
<tr>
<td>#6</td>
<td>(((((hypertension[MeSH Terms]) OR diabetes mellitus[MeSH Terms]) OR dyslipidemia[MeSH Terms]) OR diet modification[MeSH Terms]) OR exercise[MeSH Terms]) OR physical activity[MeSH Terms]) OR smoking cessation [MeSH Terms] OR body mass index[MeSH Terms]) OR weight reduction[MeSH Terms])</td>
<td>799358</td>
</tr>
<tr>
<td>#5</td>
<td>((occupational health[MeSH Terms]) OR health promotion[MeSH Terms]) OR wellness program[MeSH Terms]</td>
<td>73728</td>
</tr>
<tr>
<td>#4</td>
<td>((worksite[Text Word]) OR employee[Text Word]) OR worker[Text Word])</td>
<td>46693</td>
</tr>
<tr>
<td>#3</td>
<td>workplace[MeSH Terms]</td>
<td>12608</td>
</tr>
<tr>
<td>#2</td>
<td>internet[MeSH Terms]</td>
<td>46446</td>
</tr>
<tr>
<td>#1</td>
<td>(web-based[Text Word]) OR online[Text Word]</td>
<td>53952</td>
</tr>
</tbody>
</table>

doi:10.1371/journal.pone.0083594.t001
Common themes with the largely internet-based studies were provision of access to a web-site and a needs assessment either through questionnaires (health risk assessments, psychosocial assessments, health surveys, etc.) or through monitoring devices such as physical activity monitors or pedometers. Some interventions in the randomized trials also included the ability to self-monitor progress, email support for reminders or motivational messages, and social networking (interaction with others in the intervention). In general there was no clear pattern for the relation between the number of intervention components and the outcome among the internet-based randomized trials.

Multi-component studies appeared to be more effective, as all 4 studies (2 trials and 2 pre-post studies) found significant associations between their intervention and outcomes[29–32].

**Effects on individual outcomes**

The effects of the study interventions on the individual outcomes are graphically expressed using bar charts modified from Ogilvie et al. ‘s harvest plots[11] (figure 2). Each bar represents a study. The dark bars indicate adequacy of study design (A or B) while the lighter bars indicate inadequate study design (C, D or E). The numbers on each bar indicate the number of quality criteria met (maximum of 6). The modified harvest-plots are created for each outcome (figure 2).

Weight-related outcomes. Weight-related outcomes were the most reported among the studies included in this review. In all, twenty studies reported on weight, BMI/obesity, waist circumference, skin fold thickness, and body fat changes of which 15 were high quality studies and 5 were of low-quality. Among the high quality studies, less than half (7) reported significant improvement in any weight related outcome[12,14,16,22,23,26,29]. The same
<table>
<thead>
<tr>
<th>Author Year</th>
<th>Population</th>
<th>Interventions</th>
<th>Follow-up period</th>
<th>Key findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tate 2001</td>
<td>Healthy overweight (BMI) =&gt; 25 – 36kg/m² hospital employees Mean age 41 years IG: N = 46; CG: N = 45</td>
<td>IG - All CG interventions plus self-monitoring with e-diary; online access to therapists; weekly emails with weight loss lessons and personalized feedback; social support via e-bulletin board; CG - Website with basic information on weight loss, diet, exercise, other behavioral topics; 1 live counseling session; on weight control, PA.</td>
<td>6 months</td>
<td>Diet &amp; Physical activity: NS</td>
</tr>
<tr>
<td>Papadaki 2005*</td>
<td>Female university workers</td>
<td>All: Baseline dietary and psychosocial assessment</td>
<td>6 months</td>
<td>Lipid profile (IG vs. CG): ΔHDL mg/dl: 8.5 vs. +2.3 (p = 0.036); ΔTC/ΔHDL: −0.44 vs. −0.04 (p &lt; 0.01)</td>
</tr>
<tr>
<td>Spittaels 2007</td>
<td>Healthy workers; Mean age 39.5 yrs; TA + email N = 116; TA only N = 122; CG: N = 141</td>
<td>TA + email = Online-tailored PA advice plus reinforcement e-mails; TA only = Online-tailored PA advice only; CG = Online minimal feedback, print material on lifestyle changes</td>
<td>6 months</td>
<td>Mean Body fat (%): TA + email vs. CG = −2.1 vs. −0.9 (p &lt; 0.05); TA + email vs. TA only = −2.1 vs. −0.1 (p &lt; 0.05)</td>
</tr>
<tr>
<td>Prochaska 2008</td>
<td>University employees Mean age: 42 years.</td>
<td>IG: HRA+ tailored feedback on most important improvement step (HRI) + online TTM assessments &amp; tailored feedback +4 online tailored lifestyle intervention programs</td>
<td>6 months</td>
<td>Physical Activity % with 30 minutes of moderate exercise ≥5 days/week: IG vs. CG = 45.2% vs. 35.1% (p &lt; 0.01); MI group vs. CG = 46% vs. 35.1% (p &lt; 0.01);</td>
</tr>
<tr>
<td>Morgan 2009</td>
<td>University Males workers and students Overweight or obese IG: N = 34; CG: N = 31 Mean age = 36 years</td>
<td>IG: a face-to-face information session; Internet support through free website; dietary logs; 7 individualized emails with feedback sheets over 3 months; aimed at modification of diet and PA. CG: information session only</td>
<td>6 months</td>
<td>BMI &amp; Smoking NS</td>
</tr>
<tr>
<td>van Wier 2009</td>
<td>Healthy overweight Mean age = 45 years</td>
<td>All: Self-help materials on overweight and healthy diet.</td>
<td>6 months</td>
<td>Physical Activity (METmins/wk): ΔPG – ΔCG = 866 (p &lt; 0.05); OR of 1.8 (95% CI 1.3; 2.6); ΔAG – ΔCG: NS.</td>
</tr>
<tr>
<td>Bennet 2011</td>
<td>Managerial level staff Mean age = 42 years. G 73; IG72</td>
<td>IG: 6 month web-based health and leadership program; individually tailored to the participants; CG: No intervention</td>
<td>6 months</td>
<td>Diet Healthy diet attitude: ΔIG – ΔCG = 0.25 (p &lt; 0.01); Dietary self-efficacy: ΔIG – ΔCG = 0.43 (p &lt; 0.01); Anthropometrics (cm) ΔWC among women only, ΔIG – ΔCG = −4.0 (p = 0.02);</td>
</tr>
<tr>
<td>van Genugten 2012</td>
<td>Self-reported overweight employees &amp; general population. Mean age = 48 years IG: N = 269; CG: N = 270</td>
<td>IG - Weekly online tailored lifestyle diet, PA education/ counseling modules; online progress tracker; peer to peer forum; CG - Website with non-tailored information, non-tailored modules, no forums, no progress monitor</td>
<td>6 months</td>
<td>PA Diet BMI SFT WC: NS</td>
</tr>
<tr>
<td>Watson 2012</td>
<td>404 employees. Mean age = 50 years. Elevated SBP OR self-reported hypertension. IG: N = 197; CG: N = 207</td>
<td>IG: Home BP cuffs with readings transmitted to central server; access to web-site to view BP trends and read automated tailored messages; CG: Only access to an onsite BP machine also transmitting information to a central server.</td>
<td>6 months</td>
<td>DBP (IG vs. CG) Absolute values: 2.6 mmHg lower in IG (p &lt; 0.001); ≥5 mmHg decline: Overall was 27.4% vs. 15.9% (p = 0.034) Among those with hypertension was 51.5% vs. 26.4% (p = 0.01); SBP (IG vs. CG) Absolute values: No significant difference in change% with ≥10 mmHg decline: Overall was 21.3% vs. 16.4% (p = 0.044).</td>
</tr>
<tr>
<td>Author Year</td>
<td>Population</td>
<td>Interventions</td>
<td>Follow-up period</td>
<td>Key findings</td>
</tr>
<tr>
<td>-------------</td>
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<td>-------------</td>
</tr>
<tr>
<td>Slootmaker 2009</td>
<td>102 office workers; Mean age 32 years. IG: N = 51; CG: N = 51</td>
<td>IG - Web-based tailored PA advice based on physical activity monitor; Can set own goals; monitor activity log; lasted 3 months CG - Brochure with general PA advice only</td>
<td>8 months</td>
<td>PA, aerobic fitness, body composition NS</td>
</tr>
<tr>
<td>Papadaki 2009</td>
<td>Same as Papadaki 2005</td>
<td>IG - Web-based tailored PA advice based on physical activity monitor; Can set own goals; monitor activity log; lasted 3 months</td>
<td>9 months</td>
<td>Lipid profile (IG vs. CG): ΔHDL: 0.27 vs. 0.07 (p = 0.005); ΔTC: ΔHDL: −0.047 vs. −0.06 (p = 0.025); Diet (IG vs. CG): ΔVegetable intake g/d: 76.5 vs. 27.7 (p = 0.05); Physical Activity (moderate) IG vs. CG: coefficient = 1.149 (p = 0.013); Anthropometrics (Waist circumference) IG vs. CG NS</td>
</tr>
<tr>
<td>Hughes 2011</td>
<td>423 employees. Mean age 51 years.</td>
<td>IG - Initial web-based HRA, personalized risk profiles &amp; tailored advice on improvement CG - Printed health promotion materials</td>
<td>12 months</td>
<td>Diet % energy from fat IG vs. CG: NS; COACH vs. CG: coefficient = 2.187 (p &lt; 0.027); Fruit and vegetable consumption IG vs. CG: control vs. control coefficient = 4.366 (p &lt; 0.001);</td>
</tr>
<tr>
<td>Aittasalo 2012</td>
<td>241 Office workers Mean age = 45 years IG: N = 123; CG: N = 118</td>
<td>IG - Web-site for goal-setting, self-monitoring of weight, exercise (pedometers) and nutrition; minimal personal contact 9 months program CG - No internet support</td>
<td>12 months</td>
<td>Weight, BMI, WC, SBP, DBP, TC, LDL, HDL, TG, FPG NS</td>
</tr>
<tr>
<td>Reijonsaari 2012</td>
<td>Employees of insurance company Mean age: 43 years IG: 264 CG: 257</td>
<td>IG - Baseline fitness test, information leaflet on PA, accelerometer for monitoring of PA, website access for monitoring progress, received counseling over the telephone or web messages CG - Baseline fitness test, information leaflet on PA</td>
<td>12 months</td>
<td>Maximal oxygen uptake, weight, WC, SBP, DBP, not significant. Body fat % ΔIG − ΔCG = 0.6% greater increase in IG (95% CI: 0.2%–1.0%)</td>
</tr>
<tr>
<td>Kang 2010</td>
<td>Male industrial workers; With Type 2 DM or IFG Not treated</td>
<td>Intervention: 3 face-to-face counseling sessions on lifestyle modification (12 weeks) Follow-up emails every 3 weeks (30 weeks) OIG: N = 25, TIG: N = 25, CG: N = 75</td>
<td>24 months</td>
<td>Metabolic Profile; ΔFPG (mmol/l) vs. CG: ΔTIG = −0.83 vs. −0.17 (p &lt; 0.05); ΔIG: −0.84 vs. −0.17 (p &lt; 0.05); ΔHbA1c (mmol/l) vs. CG: ΔTIG: −0.15 vs. 0.27 (p &lt; 0.05); OIG: 0.13 vs. 0.27 (p &lt; 0.05); ΔTC vs. CG: ΔTIG = −11.12 vs. 5.75 (p = 0.05); ΔWC vs. CG: ΔTIG = −1.76 vs. 3.9 (p &lt; 0.05); Blood pressure (mmHg); ΔSBP vs. CG: ΔTIG = −10.92 vs. −0.80;</td>
</tr>
<tr>
<td>Dekkers 2011</td>
<td>As described in Van Wier et al. 2009</td>
<td>As described in Van Wier et al. 2009</td>
<td>24 months</td>
<td>Weight, WC, skin fold thickness, SBP, DBP, TC, maximal oxygen uptake; No significant difference in the change between groups</td>
</tr>
<tr>
<td>Robroek 2012</td>
<td>924 Dutch Employees IG: N = 465 CG: N = 459</td>
<td>IG: HRA; one face-to-face counseling session Website with tailored advice based on self-reported PA and diet; ability to monitor progress; online support from health professionals; monthly e-mail messages for throughout year one CG: HRA and one face-to-face counseling session</td>
<td>24 months</td>
<td>PA, Fruit &amp; Vegetable intake, Obesity, SBP, DBP, TC, maximal oxygen uptake NS</td>
</tr>
</tbody>
</table>

*quasi-experimental design

Δ = change in (− reduction, + increase); MetS = Metabolic syndrome; FG = fasting glucose; WC = waist circumference; BP = blood pressure; SBP = systolic blood pressure; DBP = diastolic blood pressure; NS = not significant; TC = total cholesterol; TG = triglycerides; FRS = Framingham risk score; HRA = health risk assessment; HRI = health risk intervention; TTM = transtheoretical model; MI = motivational interview; CVD = cardiovascular disease; HDL = High density lipoprotein cholesterol; lbs = pounds; RBG = random blood glucose; IG = intervention group; CG = control group TIG = two year intervention group; OIG = one year intervention group; TA = tailored advice; PA = physical activity; N/A = not available CI = 95% confidence interval;
doi:10.1371/journal.pone.0083594.t002
### Table 3. Summary of Longitudinal/Follow-up Studies on Internet-Based Employee Health Programs.

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Study Population</th>
<th>Intervention and Comparisons</th>
<th>Follow-up period (months)</th>
<th>Outcomes measured and results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jung, 2012</td>
<td>226 employees with ≥1 Metabolic Syndrome risk factor Mean age = 42 yrs; Subcategorized into Low risk (≤2 risk factors N=64); High risk (&gt;2 risk factors N=162) All had same interventions</td>
<td>In-person group education, individualized workplace counseling; equipped worksite e-health zones; pedometers; individualized telephone counseling based on measured parameters; Monthly email with including BP monitoring results and pedometer step counts.</td>
<td>6 months</td>
<td>Metabolic Profile: ΔTG (mg/dl) low risk = -42.8 (p = 0.0001), high risk = -35.5 (p = 0.0001), between groups = NS; ΔHDL (mg/dl) low risk = NS, high risk = NS; between groups = NS. ΔFG (mg/dl) low risk = 0.5, high risk = -6.3 (p = 0.048, p = 0.0001), between groups (p = 0.019)</td>
</tr>
<tr>
<td>Speck, 2010</td>
<td>619 participants in an academic worksite Mean age = N/A</td>
<td>Step-counting pedometer; web-site with diet information &amp; individual e-journaling, ability to share personal step totals, motivational tips, various other health-related resources</td>
<td>6 months</td>
<td>PA Goal = 10,000 average daily steps 36% of 424 met goal @ 2weeks (baseline) and 45% of 163 at follow-up and 54% of those who tracked throughout the 21 week program (N = 57). Population that tracked every week for the duration of the study = 9%</td>
</tr>
<tr>
<td>Pratt, 2006</td>
<td>2498 employees globally, Mean age (ranges) = 42 – 45 yrs</td>
<td>Website with online recipes, nutrition/fitness web-chats; online support from nutritionists &amp; exercise specialists; motivational e-newsletters; incentives; four cohorts over 4 consecutive years</td>
<td>5-7 months</td>
<td>Δfruit and vegetable intake increased over the 4 years (p &lt; 0.05) ΔPA increased (p &lt; 0.05) Δ weight yrs 1, 2 &amp; 3 = -1.4 kg (P&lt;0.05). Δ weight yr 4 = -1.8 kg (p&lt;0.05)</td>
</tr>
<tr>
<td>Colkesen2011</td>
<td>176 employees who Mean Age = 45 yrs</td>
<td>Web-based HRA &amp; individually tailored advice on healthy lifestyle (web-based health action plan); Referral for those with high CVD risk; Health counseling at request.</td>
<td>7 months</td>
<td>Framingham risk score: FRS (%) entire population = -4.9 (p = 0.017) high risk (FRS ≥20%) @ baseline = -17.9 (p = 0.001) Lipid Profile (mg/dl) ΔTC = -0.7 (p = 0.001); ΔHDL = +3.9 (p &lt; 0.001); ΔTG = +8.9 (p = 0.025). Blood Pressure (mmHg) ΔSBP = -5 (p &lt; 0.001) Anthropometrics (cm) ΔWC = -2 (p &lt; 0.001)</td>
</tr>
<tr>
<td>Moore, 2008</td>
<td>735 workers and their household members Mean age = 41 yrs</td>
<td>Web-site with information about healthy nutrition and tips on healthy exercise; Email reminders with link to web-site and article for the week. Online - Tailored DASH-diet based advice</td>
<td>12 months</td>
<td>Anthropometrics: ΔWeight (kg): All weight groups was -1.41 (p &lt; 0.01). Those with BMI≥25 was -1.90 (p &lt; 0.01). Blood Pressure ΔSBP: high BP group was -6.8 mmHg (p &lt; 0.001). Diet Δfruit = increase &amp; Δvegetables intake = increase (p = 0.03, p = 0.002). Δgrain intake = decrease (p = 0.04)</td>
</tr>
<tr>
<td>Pewz, 2009</td>
<td>214 Employees at a state DOH Mean age = NA</td>
<td>Online behavioral change program; wellness report after a HRA; Online progress tracking; Incentives for progress towards goals</td>
<td>12 months</td>
<td>Vegetable intake: Δ in % with ≥3 times/d = +12.2 (p = 0.03) Fruit intake: Δ in % with ≥3 times/d = +6.5 (p = 0.08)</td>
</tr>
<tr>
<td>Peterson 2008</td>
<td>Employees of a large multi-national company. N = 2127 Median age = NA Matched Controls N = 2127</td>
<td>Initial HRA; online-weight management tool; food &amp; weight trackers; meal planners, serving size calculators; social support, dietary assistance, emails (general and personalized); Earn points for web use and progress.</td>
<td>12 months</td>
<td>Anthropometrics: Weight Overall = 1.09 kg decrease over 6 months (p&lt;0.005). Among overweight persons = 0.78 kg reduction over 6 months. Δ Frequency of normal weight (IG vs. matched controls) = +2.3% vs. +0.3% (p &lt; 0.05)</td>
</tr>
<tr>
<td>Hotta, 2007</td>
<td>101 University staff Attempting to quit smoking; Median age = 45 yrs.</td>
<td>5 face-to-face smoking cessation classes with personalized assessments; nicotine patches; Self-help booklet; e-mails support with motivational information; Ability to send out emails to the mailing list.</td>
<td>12 months</td>
<td>Smoking Cessation 50% quit rate in population using intention to treat analysis and 53% of those who completed the one year follow-up. Writing or sending emails to the mailing list was associated with continued smoking cessation for a year (OR 5.9; p = 0.008)</td>
</tr>
<tr>
<td>Graham, 2007</td>
<td>1772 current smokers Mean age = 44 yrs</td>
<td>Website with tailored smoking cessation information, help with setting quit dates, online cessation counselors &amp; social support</td>
<td>12 months</td>
<td>Smoking Cessation - 7-day PPA 12.8% in the entire sample recruited at baseline and 43% in those that adhered to the program</td>
</tr>
<tr>
<td>Sama, 2009</td>
<td>246 Nurses; smoker (Baseline); Mean age = 45 yrs</td>
<td>Website with tailored smoking cessation information, help with setting quit dates, online cessation counselors, online social support</td>
<td>12 months</td>
<td>Smoking Cessation - 7 day PPA 43% of follow-up responders at 3 months; 45% at 6 months; 53% at 1 year</td>
</tr>
<tr>
<td>Follow-up period (months)</td>
<td>Outcomes measured and results</td>
<td>Study Population</td>
<td>Intervention and Comparisons</td>
<td></td>
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<tr>
<td>Blood pressure (mmHg)</td>
<td>Increase in the mean SBP (+3.772 p = 0.013), reduction in DBP ≥5 mmHg</td>
<td>238 employees, BMI ≥25, IG N = 101; IG +: Web-site online-tailored advice based web-based</td>
<td>McHugh, 2012</td>
<td></td>
</tr>
<tr>
<td>Metabolic profile</td>
<td>Reduction in HDL mg/dl (−7.02; p = 0.033), increase in RBG (+3.72; p = 0.028)</td>
<td>CG N = 137</td>
<td>HRA; set goals, monitor diet and PA online; Email with links to monthly tailored e-newsletters</td>
<td></td>
</tr>
</tbody>
</table>

Blood pressure. Eleven studies reported BP as an outcome, 7 of which were high quality. Five of the 7 high quality studies did not find a significant effect of the intervention on blood pressure [14,16,23,26,27] while the other two reported clinically significant reduction in BP (reduction in SBP ≥10 mmHg or reduction in DBP ≥5 mmHg) [29,30]. None of the high quality studies reporting no intervention effect on BP were conducted among at-risk populations (had elevated blood pressure).

All four pre-post studies reporting BP outcomes were of low-quality. Three of these reported a decline in BP [32,33,36], while one showed a paradoxical increase over the study period [35]. The latter was conducted in a group of overweight employees over a period of 24 months [35].

Blood glucose and HbA1c. Only one high quality study, a randomized trial, examined blood glucose profile as a study outcome [29]. This study, conducted among persons with type 2 diabetes mellitus or impaired fasting glucose over 12 and 24 months showed the internet-based intervention to be useful in reducing fasting plasma glucose (average of 12 mg/dl or 0.67 mmol/l less in the intervention group), while HbA1c was reduced only in those who received the intervention for two years [29].

The 2 pre-post studies (both low-quality) that reported blood or plasma glucose levels had contrasting results with one reporting a reduction in fasting glucose over 6 months, [32] while the other reported a significant increase in blood glucose (drawn at random) over 2 years [35].

Lipids. Six high-quality randomized studies reported on lipid profiles outcomes three of which showed improvements [18,19,29]. Among the other three high-quality studies reporting no significant intervention effect, 2 of them had follow-up periods of 2 years [15,27].

Diet. Nine high-quality studies, all randomized trials measured dietary outcomes, of which 5 found no improvements in any dietary outcome [16,17,23,25,27] while four demonstrated significant intervention effects on diet. Among those reporting improvements, the outcome measures were different. For instance, Bennet et al. [14] demonstrated improved dietary self-efficacy and healthy diet attitude, Papadaki et al. [18,19] demonstrated greater intake in fruits, nuts, and seeds in the intervention group.
compared to controls at 6 months only, while Kang et al. [29] reported lower protein and sodium intake in the intervention group (administered over 2 years) compared to controls [14,18,19,29].

Among the follow-up studies, 3 (all low-quality) demonstrated increases in fruit and vegetable intake [36–38]. One of them [36] also demonstrated a decrease in grain intake over 12 month follow-up ($p<0.05$). None showed a negative effect on dietary practices.

**Physical Activity.** Nine high quality randomized studies assessed physical activity as an outcome. Among these only one demonstrated a significant intervention effect on physical activity [20]. This study demonstrated that moderate exercise for ≥30 minutes/day on 5 or more days a week occurred 10% more in the intervention group compared to controls. In contrast, the other 9 high quality studies did not demonstrate a significant intervention effect [13,16,17,21–23,25,26,28,29].

The 2 low-quality studies that examined physical activity outcomes reported significant improvements[39,40]. Both studies measured the increase in the number of people completing 10,000 steps per day with one of them combining the use of pedometers, website access, e-journaling, and social network approaches in their intervention [40].

**Smoking cessation.** Three follow-up studies that measured smoking cessation all showed significant intervention effects though they were all assessed to be of low-quality[31,34,39].

The study with the greatest intervention effect also had the highest intervention adherence rate [31]. In this study, 50% quit rate was achieved among University staff who participated in a multi-component cessation program. None of the randomized trials had a smoking cessation program although one trial measured smoking cessation as an outcome and found no significant difference in quit rates between the intervention and the control groups[20].

**Discussion**

In general, the internet-based studies included in our review did not show consistent improvement in any of the outcomes assessed. Weight related and physical activity outcomes were the most examined and thus had the largest number of studies. Our findings show equal number of high quality studies reporting no improvement or some improvement on weight related changes.
however virtually all the high quality randomized trials showed no
effect of the interventions on physical activity. Thus we may
conclude that these types of interventions do not improve physical
activity and unpredictable effects on weight management. Among
the studies with dietary outcomes the number of high quality
studies demonstrating improvements was similar to those with no
significant intervention effect (4 vs. 5) making decisive conclusions
about the efficacy of internet-based studies on improving diet
difficult to make. More studies showed no effect on BP than
significant BP reduction. However, we note that that only one
study was targeted at persons who were hypertensive [30] and
showed clinically significant reduction in blood pressure. Thus we
conclude that general internet-based wellness interventions (multi-
hit programs) may not be effective at BP reduction and that there
is insufficient evidence to conclude for or against internet-based
interventions targeted at persons with elevated BP/hypertension.
Half of the six high quality studies examining lipid profiles showed
no improvement while the other half demonstrated improvement in
at least one parameter, thus making conclusions about internet
based studies in improving lipid profiles impossible. There were
too few high quality studies examining smoking cessation and
improvement in blood glucose or HbA1c to comment on the effect
of internet based interventions on these outcomes. This summary
is made with caution since we have observed wide differences in
intervention design, measured outcomes, populations studied and
duration of follow-up in studies included in our review.

Comparing multi-component studies to those that were largely-
internet based is difficult because of the differences in populations
and intervention types. Still, one study compared 2 different
delivery methods of the same intervention with no-intervention
controls; a multi-component arm (in-person, telephone and email
delivery), and an internet only program with similar content. This
study found that the multi-component intervention group had
significant improvements in physical activity, diet and waist
circumference reduction compared to controls, while no improve-
ments were seen in the internet arm compared to controls[16]. In
several of the studies, having an environmental component to the
intervention was more effective than having only web-based
components. For instance, Watson et al. demonstrated clinically
significant reduction in BP using a program that had internet-
based reminders but also made BP measuring machines available
in the workplace.

The impact of internet-based interventions in the long-term
could not be assessed as most of the studies included in our review
had relatively short follow-up periods with only a few lasting for
one year or more. A look at trials with one or more years of follow-
up (n = 7) showed that in over 70% (n = 5) of them no association
was found between the interventions and improvements in any of
the cardiovascular parameters measured. Two studies examining
the same intervention at 6 months and 2 years showed association
between the intervention and weight loss, waist circumference
reduction and increased physical activity reported at 6 months but
not 2 years [15, 26]. Moreover, in one of the 2 randomized trials
reporting significant findings at one or more years of follow-up, the
only improvement reported in the internet group compared to
controls was a reduction in waist circumference[16]. A similar
number of follow-up studies had follow-up periods of 12 months or
more and they generally reported significant improvements in one
or more of the outcomes. However, one study with a follow-up of 2
years reported a paradoxical increase in blood pressure, and
worsening of the metabolic profile over the study period. The
study was susceptible to areas of bias with regards to data
collection and may not be a true reflection of the long term effect
of internet based studies [35]. In general these findings may
suggest that internet-based studies are minimally effective in the
long term however there is not enough evidence to confirm this.

One of the AHA recommendations is to conduct more
workplace cardiovascular wellness research involving high risk
populations [3]. Not many high quality studies in our review were
conducted in special risk groups – overweight/obese persons, those
with diabetes mellitus/impaired fasting glucose, persons with
hypertension, and populations with mean age of 50 years or more.
Only 4 high quality studies (randomized trials) were conducted
primarily on overweight/obese workers[17,23,25,26] half of which
did not show any significant improvement. Even fewer high-
quality studies (two) were conducted in persons with a mean age of
50 years or more. Both of them showed reduction in waist
circumference [16] and blood pressure [30]. The only randomized
trial conducted in persons with diabetes or at risk for it showed
significant improvement in fasting plasma glucose, HbA1c, lipids,
diet, and reduction in systolic blood pressure [29]. Also as earlier
mentioned only one study was conducted in those with hyperten-
sion and it demonstrated clinically significant reductions in both
systolic and diastolic blood pressure [30]. More high-quality
internet based intervention studies in special risk groups need to
be conducted to determine their utility and value in these popula-
tions.

Although we found no review on workplace internet-based CV
wellness programs, several reviews on workplace wellness
programs with CV outcomes have been conducted. Our findings
on weight related outcomes were similar to those of Benedict &
Arterburn (2008) who concluded that these programs have modest
short term improvements in body weight [3]. A recent review
found small intervention effect of workplace wellness programs on
diet, noting that there was not enough evidence to comment on
the long term effect of these interventions on dietary outcomes [7].
Similarly, we do not have enough evidence to comment on the
long term effects of internet-based CV wellness programs on
dietary outcomes and the available evidence is indeterminate of its
short to intermediate effect.

A systematic review by Groeneveld et al. on workplace life-style
focused interventions to reduce cardiovascular risk concluded that
there was no effect of these programs on blood pressure, or on
serum lipids [6]. They also had too little evidence to show an effect
on blood glucose. Our findings on blood pressure are not entirely
in agreement with Groeneveld et al [6]. Even though more high-
quality studies reported no significant blood pressure changes, the
two trials conducted in at-risk groups (those with hypertension or
diabetes), demonstrated blood pressure reduction was universal
and clinically significant [29, 30]. However, like Groeneveld et al.,
only few of our studies assessed blood glucose or HbA1c making it
difficult to reach conclusions regarding the effect of internet-based
interventions on these outcomes. Improvements in lipids profile
were found in 3 of the 6 high-quality studies that examined these
outcomes. Among these, 2 were reporting the same intervention at
6 and 9 month follow-up. On the other hand, 3 pre-post studies
had improvement in the lipid profile while one showed a
reduction in HDL-c [35]. As such, similar to Groeneveld et al. [6],
we have limited evidence of an intervention effect on lipids profile.

A 2006 Cochrane review of smoking cessation programs in the
workplace found strong evidence demonstrating that interventions
directed at smokers were successful, and that interventions with
multi-components including pharmacologic therapy were more
successful in absolute terms than self-help and social support
interventions [41]. The review noted that comprehensive pro-
grams were ineffective at promoting smoking cessation [41].
Although no randomized trials with smoking cessation interven-
tions met our criteria, evidence from the follow-up studies support these findings.

Our review is limited in several ways. The decision to exclude studies with less than 6 months follow-up may have excluded well-designed studies with short follow-up. However, in our opinion, for any intervention to have significant sustained effect a minimum follow-up time of 6 months is necessary. Some studies may have fit our inclusion criteria but did not show up in our search. To minimize this we examined the references of the publications found and those of other workplace wellness reviews for relevant studies.

Due to the dissimilarity of the interventions studied, the heterogeneity of the outcomes and the disparate study design and quality, conducting a meta-analysis and interpreting its results would have been without merit. These problems along with differences in populations (varying age groups and gender distributions), cultural, and geographic regions where the studies were conducted have made it difficult to interpret the findings of the studies collectively. Finally, we cannot rule out the possibility of publication bias affecting our results.

Implications and Conclusions

With rising costs of healthcare, many organizations have turned to employee health programs as a means of reducing disease burden, productivity losses and high management costs of illness. Although there is controversy and skepticism as to the clinical utility and cost-effectiveness of these programs [42], one study indicates that employee wellness programs offer an average of 3.37 USD reductions in medical costs for every dollar spent [43]. That said, focusing on health in the workplace could only be cost-effective if the interventions are both effective and cost saving.

The success of any intervention depends on many factors including the method of delivery. Several reviews have suggested that internet delivered programs may be effective, albeit marginal at improving health behavior [44,45], managing weight [46,47], or increasing physical activity [48,49], and at least one review suggested that internet-based programs may be more effective at promoting healthy behaviors than non-internet-based interventions [45]. However, none of these reviews were conducted in primarily working populations neither did they evaluate other outcomes such as BP reduction and lipid profile changes, all of which this study does.

Our review highlights the need for internet-based workplace prevention and wellness programs to include some physical contact with participants and environmental modification to improve effectiveness however knowing the blend of internet and personal contact components for each intervention also poses significant challenge. For desired outcomes such as smoking cessation and blood pressure reduction, interventions perhaps should be tailored to the specific needs of each working population. High risk populations – persons with one or more significant risk for CVD - make up a significant proportion of the working population and are a major group that is recommended for workplace wellness programs. Unfortunately, most studies were conducted in healthy populations and as such the most effective means of delivering CV wellness programs to these populations are still unclear. Finally, for most of the reviewed programs, formulating a clear picture on their long term implications awaits further studies with longer follow-up.

Although this review demonstrates potential for success of internet-based programs at reducing cardiovascular disease morbidity as seen in weight reduction, blood pressure control and smoking cessation, much work needs to be done to understand the best approaches involving internet use in delivery of cardiovascular wellness programs and their long term effectiveness.

Adopting some standardized outcomes such as those suggested in the AHA 2020 guidelines will further help synthesize the totality of evidence about the effectiveness of these programs and provide the much needed evidence for healthcare workers, policy makers and the business community to make meaningful decisions as to the most effective ways of employing the internet in the delivery of CV wellness programs.

Supporting Information

Table S1 Methodological Criteria as Described by Ogilvie et al. (DOCX)

Table S2 Table Demonstrating Methodological Scoring for individual studies using the Ogilvie et al. criteria. (DOCX)

Checklist S1 PRISMA Checklist. (DOCX)

Author Contributions

Conceived and designed the experiments: ECA KN. Performed the experiments: ECA LLR KN. Analyzed the data: ECA LLR KN. Wrote the paper: ECA LLR WM KN. Reviewed the manuscript for content and scientific accuracy: ECA KN LLR WM ASA TF MR THT RSB M Blaha RB MIA M. Budoff.

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