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Effects of Computer Training and Internet Usage on the Well-Being and Quality of Life of Older Adults: A Randomized, Controlled Study

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The quality of life of older adults may be improved by the use of computer or Web-based services. A limited number of experimental studies on this topic have shown mixed results. We carried out a randomized, controlled intervention study that aimed to examine the causal relationship between computer use and measures of physical well-being, social well-being, emotional well-being, development and activity, and autonomy. We randomly assigned a group of 191 participants to an intervention group, a training–no intervention group, or a no training–no intervention group. A fourth group consisted of 45 participants with no interest in computer use. We collected data at baseline, after 4 months, and after 12 months. The results showed that using computers and the Internet neither positively nor negatively influenced everyday functioning, well-being and mood, and the social network of healthy older individuals. We discuss possibilities for future studies.

Key Words: Computer use—Internet—Well-being.

INDEPENDENT functioning in Western society is increasingly difficult without information technology (IT) skills, especially for older adults with less experience and more problems using IT (Czaja & Sharit, 1993, 1997; Kelley & Charness, 1995; Mead, Jamieson, Rousseau, Sit, & Rogers, 1996; Mead, Spaulding, Sit, Meyer, & Walker, 1997; Walker, Millians, & Worden, 1996). Internet-based facilities may offer specific opportunities for this age group.

The theoretically based benefits mentioned in the literature can be divided into five categories. First, the Internet may facilitate social interaction and communication (Czaja & Lee, 2001; Mead, Batsakes, Fisk, & Mykityshyn, 1999; Morrell, Mayhorn, & Bennett, 2000; Rogers & Fisk, 2000). Second, the Internet may improve entertainment and learning in the home (Czaja & Lee, 2001, 2003; Mead et al.; White et al., 1999). Third, the Internet may support autonomy by providing access to information services (Cody, Dunn, Hoppin, & Wendt, 1999; Czaja & Lee, 2003; White et al., 2002) and facilitation of routine tasks (e.g., banking and shopping; Bouchard Ryan & Heaven, 1986; Czaja, Guerrier, Nair, & Landauer, 1993; Rogers & Fisk, 2000). Fourth, there may be health-related benefits, such as improved access to health services and care givers (Czaja, 1996; Czaja & Lee, 2001; Morrell et al.; Rogers & Fisk; Stronge, Walker, & Rogers, 2001). Fifth and finally, the Internet could improve well-being and quality of life by providing mental stimulation and challenge (Jones & Bayen, 1998; McConatha, McConatha, & Dermigny, 1994; Mead et al.). The Internet may also decrease feelings of being left out of modern society (Jones & Bayen; Lawhon, Ennis, & Lawhon, 1996) and improve self-esteem and life satisfaction (Jones & Bayen; Lawhon et al.; Mead et al.; Sherer, 1996).

These categories roughly correspond to five aspects of well-being that Felce and Perry (1995) argue to be essential for quality of life: physical well-being, material well-being, social well-being, development and activity, and emotional well-being. Except for material well-being, all of these aspects are represented in the aforementioned categories. An additional aspect could be the benefits to the autonomy of older individuals.

Although the benefits of computer and Internet use seem obvious, to date only a few experimental studies have been done to substantiate these claims. In these studies, computers with several capabilities (e.g., communication, education, and recreation) were placed in care facilities for older adults and resulted in furtherance of communication (Danowski & Sacks, 1980), decreased depression ratings, increased activities of daily living and improved cognitive function (McConatha, McConatha, & Dermigny, 1994), improved satisfaction with the environment, feelings of control over daily activities and a sense of being in touch with the outside community (McConatha et al., 1995), better self-esteem and life satisfaction (Sherer, 1996), and decreased levels of loneliness (White et al., 1999). Despite these positive results, most of these studies were hampered by methodological problems such as small sample sizes, large attrition numbers, and lack of control groups. A replication of the pilot study of White and colleagues, using a larger sample of 100 participants, showed no effect with respect to quality of life as a result of 20 weeks of computer use (White et al., 2002).

We conducted a randomized, controlled intervention study to provide a methodologically more sound and powerful test of the hypothesis that using computers and the Internet is beneficial to the quality of life of older adults. It involved a large group of participants interested in learning to use computers and the Internet ($n = 191$) who were randomly assigned to conditions with or without engagement in such a cognitively challenging activity. In addition, a group of 45 individuals

without such interest participated. This total number of participants ($N = 236$) was necessary to yield sufficient power to find a medium effect size of intervention. As a result of the random allocation of computer-interested participants to three conditions and the inclusion of a fourth condition consisting of participants without computer interest, we could analyze the effects of intervention, training, and interest in the intervention separately. We did this to allow exclusion of effects of training and interest in computers on the outcome measures. For instance, the fact that individuals are interested in computers and the Internet, as well as participation in computer training, might cause changes in measures of well-being and quality of life. By including the control conditions, we found it possible to discern the effect of the intervention from possible effects of training and interest. To our knowledge, this distinction has not been made in previous studies.

To study the impact of intervention on Felce and Perry's five aspects of well-being, we used several measures; these included subjective physical well-being, social network and perceived loneliness, psychological functioning, mood, neuroticism and extraversion, activity level, and subjective activity. Because Felce and Perry (1995) stressed the importance of satisfaction with well-being, we included an additional measure of satisfaction with life. Furthermore, we added measures of activities of daily living and perceived control over life as indications of autonomy.

Methods

Participants

In the present study, we set out to recruit 240 participants. We randomly sent flyers to older adults from the Maastricht city register. We included healthy participants aged between 64 and 75 years in the study; we chose this age group to include individuals above pensionable age because they just quit working and have ample time and motivation to engage in new activities. We chose the age range to create a homogeneous group with respect to cognitive functioning, health, and lifestyle. An exclusion criterion was general mental functioning in a range that might be indicative of a cognitive disorder (score $<$ 24 on the Mini-Mental State Examination, or MMSE; see Folstein, Folstein, & McHugh, 1975). Another exclusion criterion was that participants were to have no prior active computer experience. Participants were invited to respond to the flyer by returning an application card. Participants could tick one of two options to indicate whether they were interested in learning to use the Internet or not. All participants signed a form stating they would refrain from any self-initiated computer use if they were not assigned to the intervention group during the study. Each participant signed an informed consent form. The Medical Ethics Committee of Maastricht University Hospital approved the study.

Procedure

Recruitment.—In total there were 6,054 individuals who received the flyer, and 1,016 persons applied to the study. Next, we screened 366 of the participants. Two hundred and forty individuals were eligible and scheduled for double-baseline administration of cognitive tests (results of the cognitive assessment are not discussed here). These individuals were familiarized in detail with the randomization procedure. They were aware of both the possibility of receiving a computer for 12 months and the possibility refraining from computer use for this period. Participants were also informed that they could decide to quit the program at any moment.

We excluded 126 people from the study for the following reasons: they had computer experience ($n = 54$), health-related problems ($n = 14$), or experience with tests from the test battery ($n = 11$); they were unwilling to refrain from computer use ($n = 4$); they lacked a cable TV connection (required for the Internet connection) or the space for a computer ($n = 2$); or they dropped out for no specified reason after being informed about the study's procedures ($n = 41$). After the first baseline administration, four participants dropped out of the study because they had health problems, were "too busy" or put off by the test procedure, or had a score of $<$24 on the MMSE. We administered the test battery again after 4 and 12 months, using parallel test versions. Besides the cognitive test battery, we administered a set of questionnaires on all test occasions (baseline and at 4- and 12-month follow-ups).

Initial recruitment did not yield sufficient participants who were not interested in using computers and the Internet. We sent a second invitation letter to 585 new people from the city register to recruit only additional noninterested participants. After these two recruitment procedures, the number of noninterested participants after baseline was kept at 45.

Randomization procedure.—We assigned the noninterested participants directly to the control group. We followed a two-phase randomization procedure for the interested participants. In the first phase (see Figure 1), we assigned interested participants ($n = 191$) to one of two conditions: two thirds of the participants ($n = 123$) received a brief training; one third ($n = 68$) did not receive this training and were assigned to the no training–no intervention group.

The training included three 4-hour training sessions over the period of 2 weeks. Computer instructors guided the sessions. Plenary discussions of computer and Internet topics were followed by individual assignments from a workbook. In the first session, participants learned to use a mouse, the operating system, basic computer concepts such as documents and folders, and a word processor. The second session dealt with Internet applications. Participants learned to use e-mail, a browser, and a search engine. In the final session, participants did a test including all topics that were practiced in the earlier sessions. The remaining time was reserved for practicing topics with which individual participants were experiencing difficulties. This final test and extra training allowed us to make an extra check for a sufficient level of computer skills. After the training, we assigned participants to one of two conditions in the second randomization phase: we assigned half of the participants ($n = 62$) to the intervention group and the other half ($n = 61$) to the training–no intervention group.

After training, individuals in the intervention group received a personal computer with a broadband Internet connection. They used the computer in accordance with their own personal needs. We used Internet-related assignments (once every 2 weeks in the first 4 months, once every month in the remaining

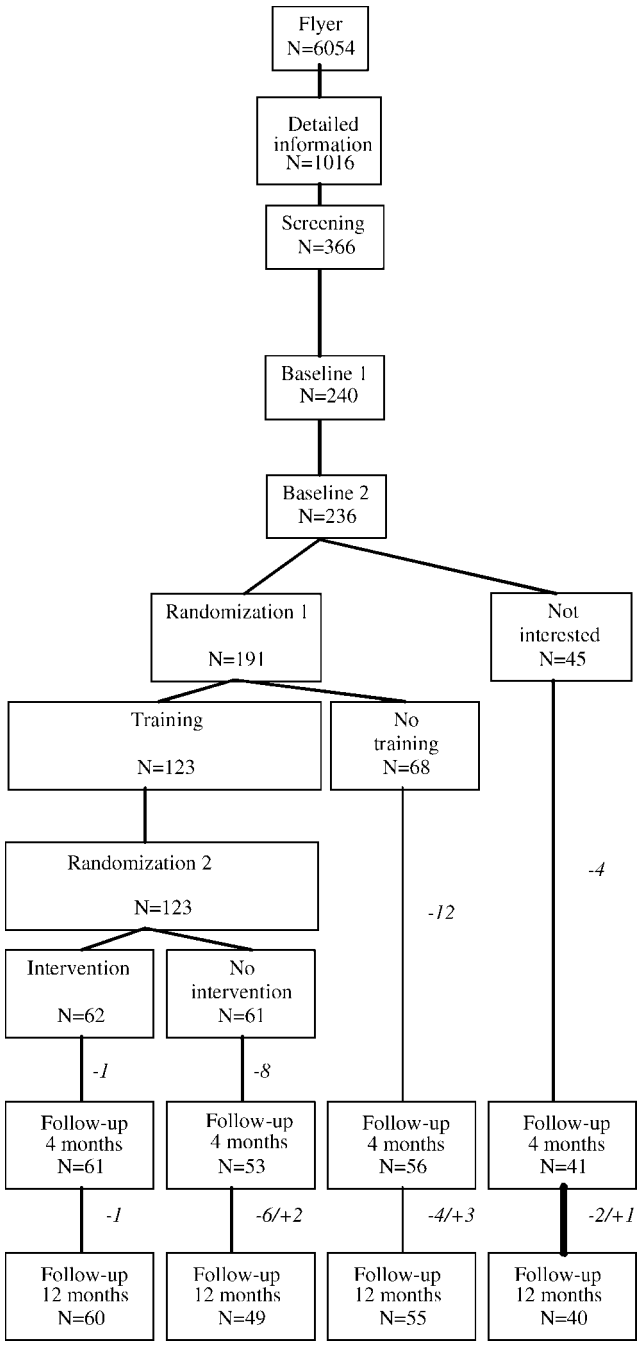

Figure 1. Flowchart of recruitment.

period) and a helpdesk to motivate participants and to stimulate computer use. We also used the assignments to monitor whether all participants were using their computers and were making sufficient progress. The assignments increased in difficulty and included finding information by means of a search engine, finding train time schedules, sending e-cards, posting messages on a forum, and so on. Computer instructors gave the participants feedback about their assignments and helped them if necessary until they were able to finish each assignment.

General procedure.—All participants were administered the same tests and questionnaires at baseline, after 4 months, and after 12 months. Participants in both of the no training groups did not have any contact with the study center besides the test administrations, and they did not receive any materials or training.

There were 19 participants who dropped out before the 4-month follow-up, and 6 participants who were not available for the 4-month follow-up itself (1 was absent for a long time, 1 did not like the tests and questionnaires, 1 was disappointed about the randomization result, 1 was too worried about his or her own memory performance, 1 could not be reached, and 1 gave no reason). These 6 participants were, however, available for the 12-month follow-up. Another 13 participants dropped out before the 12-month follow-up. There were various reasons that the participants dropped out: they had time constraints ($n = 7$), health problems ($n = 5$), or private or family problems ($n = 2$); they were absent for a long time ($n = 1$) or disappointed about randomization ($n = 5$); the partner had health problems ($n = 2$) or died ($n = 2$); they bought or received a computer ($n = 2$); they moved away ($n = 1$) or died ($n = 1$); the computer training was too much ($n = 1$); and other reasons ($n = 3$).

Baseline tests were therefore administered to 236 participants, and 204 participants completed the study (of which 6 participants had no 4-month follow-up, as previously explained). Post hoc power analyses on the available number of participants with complete follow-up data using a medium critical effect size of 0.15 and an alpha level of 0.05 resulted in a power of 0.99 for this study (Buchner, Faul, & Erdfelder, 1992).

Measures

We obtained the outcome variables of this study from questionnaire information covering aspects of well-being and of autonomous everyday functioning, as well as demographics.

Physical well-being.—To measure physical functioning, we included the physical component of the 36-item Short-Form Health Survey (SF-36), which is a questionnaire on general health and the quality of life (Ware, Snow, Kosinski, & Gandek, 1993).

Social well-being.—We measured social well-being by using the loneliness questionnaire (De Jong-Gierveld & Kamphuis, 1986). Furthermore, we included four items to measure the nature and frequency of participants' social networks. The first item concerned the number of people the participants can rely on for help and with whom they share private matters (Stevens, Kaplan, Ponds, Diederiks, & Jolles, 1999). The second item concerned the number of people the participants can rely on for help but with whom they do not discuss private matters. Both questions were followed by an indication of the frequency with which the participants contacted one of these people.

Emotional well-being.—We measured psychological functioning by using the psychological component of the SF-36. Measures of mood were provided by three subscales of the 90-item Symptom Check List (SCL-90; Arrindell & Ettema, 1986): depression, anxiety, and sleep complaints. We included two subscales of the Eysenck Personality Questionnaire (Eysenck & Eysenck, 1975): neuroticism and extraversion.

Development and activity.—We asked participants to estimate how many hours per week they engage in several activities (watching television, reading, and going to clubs; engaging in physically active sports, light sports, and mentally active sports; shopping and cooking; performing personal care; doing hobbies; learning new things; and meeting friends). We also asked participants if they considered themselves to be active people and how active they considered themselves compared with their age peers. We included a final item to ask whether participants engage in volunteer work.

Autonomy.—We included three measures of (perceived) autonomy. We used a scale for instrumental activities of daily living, which measures functional capacity by assessing whether people need any help with everyday activities such as bathing and dressing. Furthermore, we used the Belief in External Control scale (Andriessen, 1972) to measure locus of control (internal or external), and we used the Mastery scale (Pearlin & Schooler, 1978) to ask participants about their perceived level of control over life.

Measures of computer use.—To account for the extent to which individuals in the intervention group used their computer and the Internet, we had participants indicate how many hours per week they had used the computer and the Internet on average. We had these questions asked retrospectively at the end of each follow-up testing. We chose self-report data instead of logging participants' computer use for two reasons. First, it was not possible to separate participants' computer use from use by others (spouses or visiting grandchildren) without using log-in names or passwords. Second, we would have had to inform participants that we were logging their use, which may have affected the way the computer was used.

Statistical Analyses

We performed our statistical analyses with the SPSS version 11.0 program series. We conducted analyses of variance and chi-square tests on all dependent variables, the MMSE score, and a number of demographical characteristics (age, gender, education, and income as a measure of social economic status) to study differences between the four groups at baseline. We used a general linear model with a repeated-measures analysis of variance to study the effect of the intervention. We used group as a between-subject variable (four levels) and time as a within-subject variable (three levels). We defined contrasts to compare changes in performance over time. We used age, level of education, income, and gender as covariates. We were especially interested in the Time × Group interaction, as this shows whether the groups differed from one another with respect to changes. We conducted Friedman tests for dependent variables that were not interval or ratio scaled. We dichotomized some variables (instrumental activities of daily living, hours per week spent on club memberships, physically active sports, mentally demanding sports, hobbies, acquisition of new skills, and participation in volunteer organizations) and analyzed them with Cochran's Q tests.

We repeated all analyses with only the individuals in the intervention group to account for the extent of computer use. We split the intervention group into two groups (light users and heavy users), using average computer use in the 65- to 74-year-old population in the Netherlands (7 and 8 hours per week in 2003 and 2004; CBS, 2005) as the cutoff point. Because the median of computer use in this group was 7.5 hours, we used a median split method.

We checked all variables for normal distributions, missing values, and outliers. No data transformation procedures were considered necessary. We performed all analyses with and without individual cases with extreme values and finally with the replacement of extreme values by the highest values that were not labeled as extreme values (defined as more than three times the interquartile range above the 75th or below the 25th percentiles). We performed all statistical analyses with $p = .05$ as the significance level.

Results

Baseline Comparisons

At baseline the four groups did not differ with respect to demographic variables. Baseline comparisons of the outcome variables showed differences in belief in external control, $F(3, 226) = 3.13$, $p = .03$, and time spent on light sports, $F(3, 225) = 2.73$, $p = .045$. Post hoc analyses showed no differences between the groups in belief in external control and showed that participants in the training–no intervention group spent more time on light sports ($p = .03$). We did not find this difference when participants who dropped out at a later moment were left out of the analyses.

We found differences, $F(1, 230) = 6.97$, $p < .01$, between interested and not interested participants for the anxiety scale of the SCL-90: the former showed less anxiety. This difference remained when participants who dropped out were left out of the analyses.

Baseline comparisons of participants who dropped out of the study ($n = 38$) with participants who did not ($n = 198$) showed differences in level of education, $F(1, 229) = 4.13$, $p = .04$, with lower levels for dropouts; in the belief in external control, $F(1, 229) = 5.69$, $p = .02$, also with lower levels for dropouts; and the time spent on shopping, cooking, and doing personal care, $F(1, 228) = 5.30$, $p = .02$, with dropouts spending more time on these activities.

Computer Use

Participants reported using their computer an average of 8.7 hours per week ($SD = 5.8$) at the 4-month follow-up and 8.3 hours per week ($SD = 6.2$) at the 12-month follow-up. The difference between these moments was not significant. Of this time, participants spent 7.0 hours per week on the Internet ($SD = 5.6$) at the 4-month follow-up and 6.5 hours per week ($SD = 5.6$) at the 12-month follow-up. Again, this difference was not significant.

Effects of the Intervention

Results of the repeated-measures analyses are shown in Tables 1 and 2. We found no significant Group × Time interactions. We did find differences in changes over time in the frequency of contacting people whom the participants relied on for help. At both follow-ups, participants in the training–no intervention group reported seeing people they discuss private matters with less often than they did at baseline:

Table 1. Means, Standard Deviations, and Group × Time Interactions for the Outcome Variables (Range)

	Training–Intervention	Training–No Intervention	No Training–No Intervention	Control Group	Group × Time Effect p Value
Physical functioning SF-36 (20–58)	$n = 57$	$n = 46$	$n = 52$	$n = 39$	0.14
Baseline	51.71 (6.93)	52.05 (6.10)	49.42 (8.39)	50.08 (8.39)	
4-month follow-up	50.52 (7.98)	50.05 (8.14)	48.64 (7.27)	48.94 (8.66)	
12-month follow-up	49.08 (8.16)	48.22 (8.84)	48.25 (9.50)	49.57 (8.35)	
Mental functioning SF-36 (17–63)	$n = 57$	$n = 45$	$n = 52$	$n = 39$	0.10
Baseline	54.00 (8.39)	54.31 (7.25)	53.70 (6.61)	53.54 (8.02)	
4-month follow-up	51.95 (9.49)	54.34 (8.17)	54.29 (6.95)	54.11 (8.46)	
12-month follow-up	52.97 (7.98)	53.69 (8.83)	52.21 (8.93)	52.07 (10.51)	
Loneliness questionnaire (11–55)	$n = 57$	$n = 45$	$n = 50$	$n = 38$	0.84
Baseline	23.77 (6.26)	24.90 (6.81)	23.37 (7.68)	24.14 (6.25)	
4-month follow-up	24.23 (5.95)	25.57 (7.25)	24.00 (6.04)	23.56 (6.90)	
12-month follow-up	23.79 (6.37)	24.55 (6.18)	24.11 (6.06)	23.59 (5.28)	
Satisfaction with life (5–35)	$n = 56$	$n = 45$	$n = 49$	$n = 38$	0.90
Baseline	25.84 (4.77)	24.96 (4.88)	25.22 (4.59)	25.89 (4.77)	
4-month follow-up	25.48 (4.83)	24.57 (5.12)	24.33 (5.09)	25.55 (5.35)	
12-month follow-up	25.34 (4.60)	25.04 (4.86)	25.35 (4.61)	25.92 (5.06)	
SCL Depression (0–80)	$n = 55$	$n = 45$	$n = 50$	$n = 38$	0.56
Baseline	21.21 (5.74)	21.64 (6.04)	21.31 (5.20)	22.51 (5.71)	
4-month follow-up	22.92 (8.31)	21.99 (8.41)	21.95 (6.46)	22.77 (7.58)	
12-month follow-up	22.61 (8.13)	22.48 (8.15)	20.85 (5.04)	23.16 (8.01)	
SCL Anxiety (0–50)	$n = 57$	$n = 45$	$n = 50$	$n = 38$	0.13
Baseline	11.98 (2.97)	12.11 (2.67)	12.18 (2.75)	13.40 (3.70)	
4-month follow-up	12.98 (4.37)	12.66 (4.46)	12.36 (2.75)	12.82 (3.39)	
12-month follow-up	12.23 (3.25)	12.47 (5.23)	12.07 (2.43)	13.53 (3.59)	
SCL Sleep complaints (0–15)	$n = 57$	$n = 45$	$n = 50$	$n = 38$	0.89
Baseline	5.21 (2.57)	5.67 (2.87)	5.86 (2.82)	6.32 (2.90)	
4-month follow-up	5.63 (2.69)	5.37 (2.65)	6.04 (3.08)	6.26 (2.99)	
12-month follow-up	5.28 (2.38)	5.51 (2.09)	5.86 (3.06)	6.37 (2.97)	
Belief in external control (11–55)	$n = 56$	$n = 45$	$n = 50$	$n = 38$	0.92
Baseline	36.44 (6.43)	34.20 (7.49)	34.41 (6.91)	37.11 (6.99)	
4-month follow-up	36.15 (7.66)	33.14 (8.00)	33.72 (7.24)	36.87 (7.60)	
12-month follow-up	36.39 (7.22)	33.15 (7.85)	34.33 (7.71)	36.32 (8.03)	
Mastery (7–35)	$n = 56$	$n = 45$	$n = 50$	$n = 38$	0.13
Baseline	24.69 (3.62)	23.72 (4.42)	24.34 (3.43)	25.00 (3.27)	
4-month follow-up	24.61 (3.50)	23.70 (3.79)	23.52 (3.44)	25.24 (3.72)	
12-month follow-up	24.83 (3.81)	24.12 (3.90)	24.00 (3.53)	24.00 (4.30)	
EPQ Neuroticism (0–12)	$n = 50$	$n = 40$	$n = 43$	$n = 35$	0.22
Baseline	2.48 (2.43)	2.53 (2.61)	2.77 (2.86)	2.86 (2.79)	
4-month follow-up	2.74 (2.74)	2.60 (2.91)	2.19 (2.51)	2.60 (2.76)	
12-month follow-up	2.86 (2.71)	2.35 (2.94)	2.44 (2.76)	2.69 (2.76)	
EPQ Extraversion (0–12)	$n = 47$	$n = 39$	$n = 38$	$n = 32$	0.24
Baseline	6.32 (2.22)	6.56 (2.36)	6.03 (2.24)	5.53 (2.24)	
4-month follow-up	6.06 (2.52)	6.28 (2.71)	6.16 (1.97)	6.03 (2.39)	
12-month follow-up	5.94 (2.51)	6.18 (2.62)	6.05 (2.39)	5.59 (2.20)	
Private matters	$n = 51$	$n = 40$	$n = 43$	$n = 37$	0.92
Baseline	6.35 (4.77)	5.49 (4.51)	6.28 (5.00)	5.19 (3.95)	
4-month follow-up	5.82 (4.30)	5.29 (3.61)	6.49 (4.82)	4.97 (3.72)	
12-month follow-up	6.37 (4.11)	5.17 (4.15)	5.86 (3.77)	5.51 (3.62)	
No private matters	$n = 49$	$n = 31$	$n = 38$	$n = 32$	0.45
Baseline	4.39 (4.39)	2.63 (2.17)	3.76 (4.69)	2.97 (2.96)	
4-month follow-up	4.35 (4.34)	2.69 (2.35)	4.42 (4.25)	3.19 (2.51)	
12-month follow-up	4.61 (6.19)	4.75 (4.70)	3.87 (2.72)	4.00 (3.65)	

Note: SF-36 = 36-item Short-Form Health Survey; SCL = Symptom Check List; EPQ = Eysenck Personality Questionnaire; private matters = number of people the participants contacted with whom they discuss private matters; no private matters = number of people the participants contacted with whom they do not discuss private matters.

Table 2. Means, Standard Deviations, and Group × Time Interactions for the Number of Hours That Participants Engage in Several Activities

	Training–Intervention (n = 56)	Training–No Intervention (n = 47)	No Training–No Intervention (n = 53)	Control Group (n = 39)	Group × Time Effect p Value
Watching television					0.02
Baseline	15.77 (7.93)	17.09 (8.38)	15.38 (9.31)	16.88 (9.28)	
4-month follow-up	16.70 (8.98)	19.29 (8.99)	16.69 (10.08)	17.62 (8.65)	
12-month follow-up	15.16 (7.98)	17.85 (8.30)	16.20 (9.52)	18.85 (9.13)	
Reading					0.13
Baseline	11.17 (7.91)	10.67 (7.08)	10.26 (6.44)	10.61 (4.54)	
4-month follow-up	11.25 (7.30)	12.35 (6.61)	9.76 (6.27)	12.14 (6.09)	
12-month follow-up	9.91 (7.16)	9.12 (5.82)	10.49 (6.61)	11.97 (6.23)	
Light sports					0.29
Baseline	8.13 (6.21)	10.06 (9.53)	6.50 (6.13)	7.44 (5.65)	
4-month follow-up	6.42 (4.79)	8.39 (6.60)	6.14 (4.79)	7.05 (4.61)	
12-month follow-up	6.73 (5.31)	9.48 (9.05)	7.07 (6.00)	8.23 (5.71)	
Grocery shopping, cooking, etc.					0.09
Baseline	13.10 (10.64)	11.59 (8.66)	11.77 (8.90)	10.84 (7.91)	
4-month follow-up	11.67 (8.23)	12.10 (9.21)	12.36 (7.14)	12.99 (9.60)	
12-month follow-up	10.23 (6.29)	10.12 (6.03)	11.98 (8.55)	9.36 (6.39)	
Meeting with friends					0.49
Baseline	5.66 (5.61)	5.34 (3.81)	6.44 (5.12)	5.80 (4.80)	
4-month follow-up	5.46 (4.59)	5.39 (5.00)	6.45 (4.39)	5.24 (3.93)	
12-month follow-up	6.14 (5.41)	5.19 (4.30)	5.76 (4.34)	5.46 (3.93)	

$\chi^2(2, n=44) = 7.93$, $p = .02$. The same was true for the number of people with whom participants did not discuss private matters: $\chi^2(2, n = 39) = 9.65$, $p = .01$. We did not find significant changes for the other groups. The number of people participants relied on did not change for any of the groups.

We also found differences between the groups in changes over time (see Table 3) for time spent on watching television: $F(3, 185) = 2.59$, $p = .02$. However, our post hoc analysis showed no differences. We found changes within groups in the intervention group with regard to learning new things: $Q(2, n = 55) = 26.18$, $p < .01$. More time was spent on learning new things at the 4-month follow-up than it was at baseline (see Figure 2). In addition, scores relating to whether participants consider themselves to be active people changed for the no training–no intervention group: $\chi^2(2, n = 50) = 17.27$, $p < .01$. Participants in this group considered themselves less active at the follow-ups than at baseline. Finally, time spent on volunteer work changed for the training–no intervention group: $\chi^2(2, n = 46) = 8.36$, $p = .02$. These participants spent less time on volunteer work at the 4-month follow-up than they did at baseline and at the 12-month follow-up. Repeating all analyses with exclusion or replacement of extreme values did not yield different results.

We found no significant differences between light and heavy computer users at baseline. Repeated-measures analyses revealed an interaction between extent of computer use and time for the Mastery questionnaire, $F(2, 48) = 3.31$, $p = .04$, showing that between baseline and the 12-month follow-up, heavy users showed an increase on the Mastery scale whereas light users showed a decrease ($p = .01$). Post hoc analyses (paired t tests with Bonferroni correction) revealed that the increase between baseline and the 12-month follow-up of the heavy users was significant after Bonferroni correction, $t(23) = -2.27$, $p = -.03$, whereas the decrease of the light users was not. The partial eta squared (η^2) of the time by extent of computer

Table 3. Percentages of Participants in Each Group Who Stated They Engage in Several Activities

	Training–Intervention (n = 56)	Training–No Intervention (n = 47)	No Training–No Intervention (n = 53)	Control Group (n = 39)
Participating in clubs				
Baseline	52.2	49.2	51.5	48.8
4-month follow-up	52.2	53.8	48.2	50.0
12-month follow-up	51.8	48.9	54.7	43.6
Physically active sports				
Baseline	44.3	27.1	30.3	32.6
4-month follow-up	44.3	36.5	44.6	40.5
12-month follow-up	42.9	34.0	35.8	35.9
Mentally active sports				
Baseline	67.2	50.0	59.1	60.5
4-month follow-up	67.2	54.7	60.7	66.7
12-month follow-up	67.9	38.3	64.2	61.5
Hobbies				
Baseline	72.1	72.9	71.2	60.5
4-month follow-up	75.4	73.1	73.2	73.8
12-month follow-up	71.4	59.6	69.8	71.8
Learning new things				
Baseline	14.8	27.1	21.2	14.0
4-month follow-up	57.4	28.8	30.4	28.6
12-month follow-up	39.3	19.1	20.8	17.9

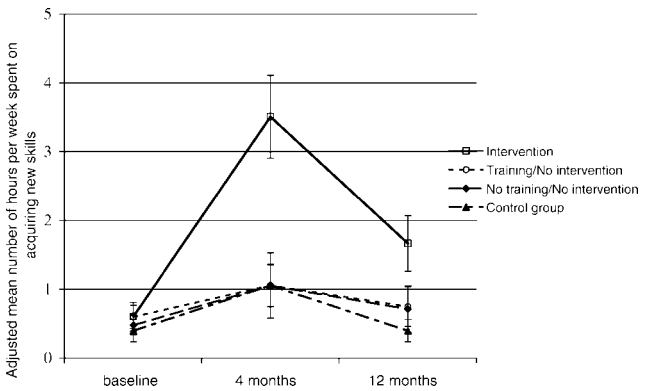

Figure 2. Mean (*SEM*) number of hours spent on acquiring new skills for each group at the three moments of measurement.

use effect is .077, indicating that the unique proportion of explained variance of this effect is 7.7%.

We found significant changes over time for the frequency of meeting people with whom the participants share private matters [light computer users showed an increase between baseline and the 4-month follow-up and a decrease after the 4-month follow-up, with $\chi^2(2, n = 24) = 8.23$, $p = .01$], for the time spent on hobbies [heavy computer users showed an increase over all time intervals, $Q(2, n = 24) = 6.33$, $p = .04$], and for the time spent on acquiring new skills [light users showed an increase between baseline and the 4-month follow-up but it decreased again after the 4-month follow-up to the baseline level, $Q(2, \mathrm{n} = 24) = 16{,}55$, $p < .01$]. Heavy users also showed an increase between baseline and the 4-month follow-up but only a slight decrease after the 4-month follow-up; $Q(2, 24) = 11.41$, $p < .01$.

Discussion

The main question of this study was whether or not, for older adults, learning to use a computer and the Internet for 1 year has an impact on well-being and quality of life. Earlier studies yielded inconsistent results and used methodologically less accurate designs. We therefore used a rigorously controlled, randomized design to account for these drawbacks and to provide an unambiguous answer. However, we found no clear-cut effect of intervention for the majority of these measures. The differences that we did find were quite random and did not appear to be caused by the intervention. The only exception is the fact that participants in the intervention group spent more time on learning new things, which was to be expected as these participants learned to use a personal computer and the Internet.

We did find differences in changes over time between heavy computer users and light computer users. Heavy users showed an increase in mastery, whereas light computer users did not. Thus, participants who used their computers more often felt more in control of their lives as a result of their frequent computer use. In addition, heavy computer users gradually reported spending more time on their hobbies, which is probably due to the fact that they started a new hobby: using a computer. They also had enhanced access to hobby-related activities on the Internet. Both heavy and light computer users reported spending more time on acquiring new skills at the 4-month follow-up than at baseline. As we anticipated, after the 4-month follow-up the time spent on new skills dropped to the baseline level for participants who did not use their computers very often, although this time dropped only slightly for the participants who used their computers more frequently. A final variable in which we found a change over time was the frequency with which participants reported contacting people with whom they discussed private matters. For the heavy computer users, this frequency was stable during the study; for light users, the frequency temporarily increased at the time of the 4-month follow-up. These differences appear rather unsystematic and may be a chance finding.

In short, the lack of differences between the intervention group and the other groups over time does not confirm the hypothesized positive effect of learning to use the Internet on quality of life. These findings do not correspond to results of most studies that used, to some extent, similar interventions (Cody et al., 1999; McConatha et al., 1994, 1995; Sherer, 1996). However, these differences in findings may be attributable to several factors, which we subsequently discuss here.

The most important differences concern methodological issues. Almost without exception, the earlier studies used fewer participants and less systematic designs; a number of them reported quite dramatic attrition numbers. The notion that methodological issues, such as the number of participants, are important in considering the results of intervention studies is supported by the fact that, in another study using a respectable sample size (White et al., 2002), also no effect of computer use was found on several psychosocial measures.

Another important methodological issue is that, in most previous studies, no care was taken to control for social contact in the intervention group as a result of training or the use of a personal computer in a shared environment (McConatha et al., 1995). This social contact may have caused contamination of the intervention effect. In our study, we accounted for this effect by including the training–no intervention group, which received the same training as the intervention group did. Following the same line of reasoning, the question is often raised as to whether an effect of intervention should be attributed to the intervention itself or to uncontrolled characteristics of the individuals who choose to participate. For instance, participants could decide to participate in a study because they expect to gain attention, expand social contacts, learn new skills, and so on. These motives could influence participants' test results, because, for example, they (unconsciously) try harder or have more positive attitudes. In this study, the inclusion of a group of people who enrolled for the intervention but who were eliminated from the training and the intervention by randomization (the no training–no intervention group) made it possible for us to study the effect of our intervention separately from such effects.

The current study also focused on healthy older adults living independently, whereas most of the aforementioned intervention studies included residents in care facilities. Our study population may have been a particularly fit group of older adults who were not (yet) limited in their physical, mental, and social capabilities. This was observed in many of the outcome variables, where mean scores were near the minimum or maximum score (e.g., both SF-36 measures, the Loneliness

questionnaire, all SCL measures, and the Eysenck Personality Questionnaire neuroticism measure). The lack of effect of intervention may therefore be due to a restricted range in functional limitation in this group, with only limited gain to be expected from the intervention. Possibly, the intervention in this study is more effective for older adults with functional limitations.

The fact that our sample size was adequate and that rigorous experimental control was used reinforces our conclusion that no effect of computer and Internet usage on health and well-being is to be expected among community-dwelling older adults. Regarding potential benefits of computer and Internet use mentioned earlier, we found no evidence for a positive effect on quality of life. However, some anticipated benefits of the Internet are hard to quantify and measure with currently available instruments. For example, being able to use computers could make older adults feel more competent to keep up to date and decrease feelings of being left out. Furthermore, feelings of involvement in the modern, IT-driven experiences of their children and grandchildren may increase. However, the changes that are brought about by this ability are probably too subtle or may become manifest in areas different from the areas focused on in this study.

One aspect we could not account for is a possible difference between individuals who take the initiative themselves to change their lifestyle and individuals who are only inclined to make such a change when a special opportunity is offered, for example by participating in the current study. In other words, providing an intervention to research participants might not yield the same results in a group of people who take action themselves. However, this is an assumption that has yet to be tested.

Another methodological issue that might have influenced the findings of this study is the fact that we used self-report measures of well-being and quality of life. At two moments in time after the start of the intervention, participants were asked to self-rate several aspects of well-being and experienced quality of life at that moment. Although the measures that we used are widely acknowledged as valid and robust measures, it must be kept in mind that these are subjective measures and that they reflect experienced well-being and quality of life at a specific moment.

A final aspect of this study that could have influenced the results is the duration of exposure to the intervention. It could be argued that, on one hand, 1 year is too short to cause substantial changes. On the other hand, if changes in everyday performance and well-being cannot be detected after 1 year, we expect that such changes are also not likely to occur after a longer time. Nevertheless, it is possible that participants who have experienced the opportunities of the Internet will cope more effectively with age-related challenges to autonomy not yet prevalent in our study sample. It is possible that including individuals older than the present participants might have yielded different outcomes. Studying the effects of Internet usage for more than 1 year, to focus on possible beneficial effects of using computers when encountering age-related disabilities, will be difficult because of the increasing number of older persons who have started using computers for their personal use. This makes another randomized, controlled trial in this area in the future rather unlikely.

An interesting difference that we found but that does not involve the effect of the intervention was a baseline difference in anxiety between interested and noninterested participants. This finding suggests a relationship between anxiety and willingness to adopt computer technology, which has been described by other authors as well (e.g., Ellis & Allaire, 1999). Another, related difference concerns differences in level of education and time spent on everyday activities between dropped-out and remaining participants. It seems that older adults with lower education levels and who need more time for everyday tasks are more prone to lack of technology adoption.

Summing up, we state that, in spite of scanty reports of a positive influence in earlier studies, we did not find consistent evidence for an impact, either positive or negative, of using computers and the Internet on several aspects of well-being and autonomy of healthy older adults. This implies that, in order to improve the quality of life of healthy older adults, the benefits of computer and Internet-related activities for personal use are limited. In our opinion, future research should aim at identifying populations more sensitive to Internet-based interventions. The question remains of whether or not older adults who have received timely training to use computers and Internet services are able to profit from this skill at the moment they are faced with functional limitations.

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