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# Impact of a digital and conventional prevention program on work ability, physical health, and mental health among employees with initial impairments

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## Abstract

**Background** This quasi-experimental study aimed to compare the effectiveness of a digital prevention intervention on work ability, physical health, and mental health with a conventional prevention program for employees with initial impairments. The study recruited 245 participants, of whom 173 completed the study, 98 (65 female, 66.3%) in the intervention group and 75 (55 female, 73.3%) in the control group. Both groups received prevention programs, with the intervention group using the Caspar digital platform and the control group using the conventional BETSI/RV Fit program. There were three measurement points in the study: T0 before the intervention, T1 in the middle of the intervention, and T2 at the end of the intervention. Participants' health was assessed using the SF-12 health status questionnaire, while their work ability was measured using the short version of the Work Ability Index.

**Results** Repeated-measures analyses of variance indicated that both prevention programs were effective in improving work ability and mental health, while physical health did not show any significant improvement. Additionally, the results of the study suggest that younger individuals benefited more from the digital prevention intervention, while older individuals benefited more from the conventional prevention program.

**Conclusion** The study emphasizes the need for further research and improvements in both research and practice. Future studies should include larger sample sizes, randomized controlled trials, and follow-up assessments to enhance understanding of the effectiveness and the durability of effects of prevention programs.

**Keywords** Digital prevention, Work ability, Health

## Background

One of the greatest challenges facing Western societies is demographic change, reflected in a declining number of younger people and a growing number of older people. For example, in Germany in 2021, for every 100 people of working age between 20 and 65, there were around 37 people of pensionable age, i.e. over 65 [1]. This trend will intensify in the coming years as the baby boomers reach retirement age, posing a major

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challenge for the country's social systems. Therefore, a well-functioning health care system plays a crucial role in maintaining the workforce's ability to work at a high level.

Prevention is a critical aspect of maintaining and promoting overall health and well-being, as evidenced by numerous public health studies. For instance, a systematic review and meta-analysis of 78 studies found that lifestyle interventions, including health behaviors such as healthy diet and exercise, were effective in reducing the incidence of type 2 diabetes [2]. Similarly, a study on the impact of preventive care in the United States found that preventive services were associated with improved health outcomes and reduced health care costs [3]. In addition to physical health, prevention also plays a significant role in promoting mental health [4]. Research has demonstrated the effectiveness of stress reduction techniques and therapy in preventing and treating mental health conditions such as depression and anxiety [5]. By taking proactive measures to prevent disease and injury, individuals and the society as a whole can reap numerous benefits, including improved health outcomes [6], reduced healthcare costs [7], and enhanced quality of life [8, 9].

With the aim of promoting healthy living and working strategies among the workforce in Germany at an early stage, the German Pension Insurance launched the nationwide prevention program *BETSI* (Bundesweites Netzwerk zur betrieblichen Eingliederung) in 2013 and renamed it *RV Fit* in 2020. The theoretical approach behind RV-Fit is based on a bio-psycho-social model that takes into account the physical, psychological, and social aspects of health [10]. This model aligns with the World Health Organization's International Classification of Functioning, Disability, and Health (ICF) [11]. The ICF views health and disability as a continuum and recognizes that both personal and environmental factors can influence an individual's functioning. The RV-Fit approach attempts to consider the complex interaction of these factors by providing individualized assessment and intervention to meet the specific needs of each person.

BETSI/RV Fit works with employers to develop and implement effective reintegration plans for employees who are experiencing initial health impairments that impact their ability to work. These initial health impairments may be characterized by the following possible features: a) pain complaints in the musculoskeletal system (e.g., back pain), b) health impairments related to internal organs (e.g., high blood pressure, obesity), c) psychological impairments (e.g., occupational overwhelm, stress), d) individual risk factors such as smoking, poor dietary habits, or lack of physical activity, and e) unfavorable working conditions (e.g., stress due to shift work, workload density, performance pressure, noise, cold, heat, monotonous standing or sitting posture, etc.).

The program advises and supports employers on issues such as workplace adaptations, job accommodations, and modified work schedules for employees. BETSI/RV Fit also works closely with healthcare providers to ensure that employees receive the necessary medical care and rehabilitation services (see also Methods section). There is some evidence that the BETSI/RV Fit program has been successful in supporting the reintegration of employees with health issues back into the workplace. According to a prospective study by Kittel et al. [12], participation in BETSI/RV Fit was found to be associated with significant reductions in risk factors such as physical inactivity, stress, and obesity, leading to better health outcomes and a positive subjective prognosis of work ability. Despite the evidence of the effectiveness of BETSI/RV Fit, however, there are challenges related to access and implementation. For example, access to appropriate facilities offering BETSI/RV Fit can be difficult, especially in rural areas.

Digital health promotion and prevention programs have gained increasing popularity in recent years due to their potential to address public health concerns on a larger scale, to reduce healthcare costs, and to provide access to evidence-based interventions to individuals who may otherwise have no access to traditional prevention programs [13]. Digital health promotion and prevention programs use digital technologies such as mobile applications, websites, and social media platforms to deliver health education, monitoring, and intervention programs aimed at promoting healthy behaviors and preventing chronic diseases [14]. Several studies have suggested the potential of digital prevention programs in promoting healthy behaviors, preventing chronic disease and assisting with weight loss [15]. For instance, a study with a randomized wait-list controlled trial design found that a self-administered web-based intervention that targeted physical activity and healthy eating behaviors resulted in significant reductions in body mass index, body fat mass, and blood glucose [16]. In addition, a systematic review of 41 studies showed that several mobile phone applications were effective in increasing health behaviors such as physical activity [17].

Despite the demonstrated benefits and potential of digital prevention programs to promote healthy behaviors and prevent chronic diseases on a larger scale, there are few studies in Germany that address the effectiveness of digital prevention programs. Little is known about the effectiveness of digital prevention programs compared to traditional prevention programs such as BETSI/RV Fit. To address these research gaps, this study aimed to examine the effectiveness of a digital prevention intervention

on work ability, physical health, and mental health of employees who are experiencing initial impairments. The effectiveness of the intervention was tested in comparison with the conventional prevention program BETSI/RV Fit. The study also aimed to examine the influence of age and gender on the effectiveness of the interventions. In addition, we wanted to investigate to what extent age exerts an influence on the effectiveness of digital and conventional prevention.

## Methods

### Design of the study

This study was registered at the German Register of Clinical Studies (DRKS) with the registration number: DRKS00024836. This study had a quasi-experimental design with two groups and three measurement time points. Participants in the experimental group were recruited from a clinic that offered the digital prevention program to its patients. In order to compare this treatment with the conventional prevention program, it was necessary to recruit participants from other clinics offering only the conventional program. Therefore, it was not possible to randomize the study participants. In addition, it is important to mention the researcher were not blinded to the assignment, however, they did not have any direct contact with the participants throughout the entire intervention. The intervention group received a digital prevention program, and the control group received the conventional prevention program BETSI/RV Fit. The first measurement time point (T0) took place immediately before the prevention intervention, the second measurement time point (T1) in the middle of the prevention intervention (12 weeks after the start of the intervention) and the third measurement time point (T2) at the end of the intervention (24 weeks after the start of the intervention). The study started with an inpatient or outpatient stay for the control group for three to five days and an inpatient stay for the intervention group lasting 14 days. Participants in the intervention group stayed at the Knappschafts-Klinik Borkum, where the digital prevention program was used, and participants in the control group stayed at one of the participating prevention clinics or health centers offering BETSI/RV Fit (i.e., Ambulantes Zentrum für Rehabilitation und Prävention am Entenfang in Karlsruhe, Fachklinik Sonnenhof GmbH in Höchenschwand, and Prevention Center Darmstadt). Participants in the two groups were recruited at the respective clinics or health centers.

The baseline measurement (T0) was conducted during the clinic stay, during which participants received the questionnaires, an informed consent form, and a contact sheet. Participants returned these documents to the study management, which ensured strict compliance with the data protection guidelines of the Karlsruhe Institute of Technology (blinded for review). At the second and third measurement time points (T1 and T2), the participants were provided with the necessary documents directly by the study management, either by e-mail or mail, as requested by the participants. The same procedure was used for both groups. The study was conducted in accordance with the tenets of the Helsinki Declaration and approved by the Data Protection Officer and the Ethics Committee of the Karlsruhe Institute of Technology (328–18 1200).

### Sample

Participants for the study were recruited from December 2019 to October 2022 through the Knappschafts-Klinik Borkum for the intervention group and various health centers and specialist clinics for the control group. Potential participants were identified by healthcare professionals who assessed eligibility based on specific criteria, including being an employee covered by pension insurance and experiencing initial signs of impairment such as musculoskeletal pain, internal organ ailments, or individual risk factors like smoking or poor nutrition. Individuals were also required to enroll independently in the designated prevention course. Based on the assumption of a small effect size ($f=0.10$), an alpha error rate of 0.05, two groups, three measurement time points, a correlation of 0.50 among repeated measures, and utilizing an ANOVA with repeated measures for evaluation, the required sample size was $N=164$ in order to achieve a statistical power of 0.80. Recognizing that some subjects may drop out during the longitudinal study, the goal was to recruit 240 subjects at the first measurement point. The study recruited a total of 245 subjects for the first measurement time point, prior to the implementation of the intervention. Of these, 147 subjects (88 female; 59.9%) were in the intervention group, and 98 subjects (69 female; 70.4%) were in the control group. Participants who missed at least six consecutive weeks of sessions were excluded from the study, and additionally, eight participants who reported no participation in conventional or digital prevention at any of the measurement time points were also excluded. Data from 173 subjects who completed questionnaires at all three measurement time points were analyzed. Among these 173 study participants, 98 (65 female; 66.3%) were in the intervention group, and 75 (55 female; 73.3%) were in the control group. The mean age of the intervention group at the start of the inpatient prevention intervention was 51.5 years ($SD=7.8$), while the mean age of the control group participants at the initial inpatient phase was 51.9 years ($SD=7.8$). Regarding employment status, 78 individuals in the intervention group were employed

full-time and 20 (20.4%) were employed part-time. In the control group, 51 individuals were employed full-time and 24 (32.4%) were employed part-time.

### Measures

Two validated questionnaires were used to assess health and work ability. Work ability was measured using the Work Ability Index (WAI) [18] and health using the SF-12 [19]. The questionnaires are described below.

#### *Health*

Health was measured by the licensed SF-12 health status questionnaire, whose license was obtained for the purpose of the study. This is the short version of the SF-36 [19]. The SF-12 includes the two subscales physical health and mental health. This questionnaire, which can be applied independently of the current state of health, was shown to be a suitable measurement instrument for assessing subjective health [19]. The response format contains different multilevel Likert scales as well as dichotomous scales. In terms of reliability, study results showed an internal consistency (Cronbach's α) of 0.83 for physical health and 0.87 for mental health [19]. Regarding the validity of the questionnaire, the question wording was rated as comprehensible and relevant across samples [20]. There is a representative database for the SF-12 and, therefore, the data can be compared with a norm group [21].

#### *Work ability*

The freely available short version of the Work Ability Index by Hasselhorn and Freude [18] was used to assess work ability (www.wainetzwerk.de). The questionnaire consists of 10 items with categorical and continuous response formats. Seven dimensions are mapped: I. current work ability compared to the best ever work ability, II. current work ability to current work demands, III. number of diseases currently diagnosed by a physician, IV. estimated impairment of work ability due to diseases, V. sick leave days in the past 12 months, VI. assessment of own ability to work in the last two years, and VII. mental performance reserve. The total score of the scale varies between 7 and 49 with higher values reflecting higher work ability. The reliability of the scale is Cronbach's alpha of 0.78 [22]. The validity of the scale has been demonstrated by its ability to predict early career exit and duration of work disability [23, 24].

### Intervention

This research involved the implementation of two intervention programs, namely the conventional face-to-face prevention program (BETSI/RV Fit) and the digital intervention program. These interventions were administered by a qualified physiotherapist who determined the contents of the program. In the digital program, patients who did not regularly use the app were encouraged by the intervention provider to remain engaged. Throughout the interventions, patients in both programs were under the continuous supervision of certified therapists. In the event of potential adverse effects resulting from the prevention, patients could be referred to appropriate treatment.

#### *Intervention group*

The Knappschafts-Klinik Borkum has developed a prevention concept that incorporates a digital program. For participants, the program involved a 14-day inpatient stay in Borkum. Upon arrival on Borkum, participants underwent a comprehensive assessment to identify their specific needs, challenges and goals. This phase included one-on-one interviews, health screenings and baseline measurements to tailor the subsequent program to the individual's needs. After the initial assessment, participants entered the phase that formed the core of the intervention. This phase included an intensive, structured series of exercises, therapies, and educational sessions targeting the physical, mental, and social aspects of health. In this phase, the focus was on skill development, empowerment, and self-management strategies so that participants were equipped with the tools and knowledge they need to maintain and improve their health and ability to work. During the inpatient stay, each patient received an individual training plan, which was practiced with Caspar and served as the basis for the subsequent aftercare with the Caspar digital platform. At the end of the inpatient stay, participants practiced returning to their daily lives and using the digital application. This final phase of the program reinforced the skills and knowledge acquired and ensured that participants can confidently apply what they have learned. Interactive workshops, follow-up assessments and personalized feedback helped participants integrate the principles of the program into their daily routines and work environment. After this, the participants were provided with six months of aftercare via the Caspar digital platform (https://caspar-health.com/en-us). For this six months of follow-up support, the digital platform Caspar included an individualized training plan designed by the clinic for each participant, supplemented by additional content such as modules on nutrition and relaxation techniques. The application's functionality extended to allow interactive communication between participants and therapists via integrated interfaces within the Caspar platform. This feature facilitated ongoing collaboration and served as a vital connection linking participants with therapeutic

professionals, thus augmenting the continuity and cohesiveness of the intervention.

#### *Control group*

BETSI/RV Fit was a multi-phase intervention with different variations in its implementation andtypically comprised four phases. The initial phase of the intervention spaned a few days and could be conducted on an inpatient or outpatient basis. This phase included comprehensive medical supervision, including the availability of therapeutic and medical experts for consultation purposes to accurately assess individual health needs. As in the digital prevention, personalized prevention goals were established during one-on-one consultations with healthcare professionals. Various training sessions were also held to promote positive health behaviors. Participants could engage in workshops or seminars, covering essential topics such as increased physical activity, healthy eating habits, and effective stress management techniques. The interaction with healthcare professionals during this phase ensured that participants' unique health requirements were carefully identified and appropriately addressed. The training phase of the program lasted up to three months, during which participants attend weekly outpatient courses tailored to help them achieve their specific prevention goals. These courses can include fitness classes, nutritional counseling, or behavioral therapy, aiming to form long-term habits. The self-initiative phase spaned approximately three months and placed an emphasis on personal initiative and responsibility. During this period, participants worked independently to adapt the behaviors they have had learned, using resources and strategies provided earlier during the training phase. They may have engaged in regular check-ins with healthcare providers who monitored their progress, offered guidance, and provided support as needed. The refresher phase, serving as the final part of the program, convened participants in a group setting for a day or more to evaluate the overall effectiveness of the entire prevention program. This phase provided an opportunity to review and reaffirm goals, and discuss both challenges and successes. Beyond mere reflection, the refresher phase also served as a platform for future planning, allowing participants to set new goals and ensuring they have continued support and motivation for maintaining a healthy lifestyle.

### Statistical analyses

The data analysis involved three sequential steps. The first step involved computing means, frequency distributions, standard deviations, and correlations between the recorded variables using descriptive statistics. A t-test was conducted to determine significant differences between the two groups at time T0 for the continuous variables, while a chi-square test was utilized to examine gender differences. The second step involved conducting repeated-measures analyses of variances to investigate the effects of the two interventions and compare their outcomes. Within-subject contrasts with linear and quadratic trends were reported in the context of ANOVA analyses, with work ability, mental health, and physical health being dependent variables and time and group membership being independent variables. In the third step, the same analysis of variance was conducted, incorporating age and gender as covariates. We expected a three-way interaction among time, age, and group for the mental health variable. To achieve this, the age variable was dichotomized at 47, with individuals older than 47 years classified as older participants and those exactly 47 years old and younger as younger participants. In addition, we also checked for the influence of the employment status, but it did not affect the results andwe have not presented the results in this manuscript. All analyses were performed with a significance level of 5%. In the correlation matrix (Table 2), $p$-values were adjusted for multiple testing using the Bonferroni-Holm correction method. Participants excluded from the study due to dropout were statistically comparable to the 173 participants included in the analysis in terms of variables used in the study. Little's MCAR test was performed with variables at all three measurement time points and yielded a nonsignificant result ($\chi 2 = 32.6$; df = 46; $p = 0.93$), indicating that the missing data did not exhibit a systematic pattern.

## Results

### Descriptive analyses

Table 1 displays the descriptive statistics. The results indicate that there were no statistically significant differences between the two groups regarding work ability ($t = 0.5$; df = 171; $p = 0.61$), physical health ($t = 1.3$; df = 171; $p = 0.20$), mental health ($t = 1.4$; df = 171; $p = 0.17$), age ($t = -0.3$; df = 171; $p = 0.74$), and gender ($\chi^2 = 1.0$; df = 1; $p = 0.32$) prior to the commencement of the intervention.

Table 2 displays the correlation matrix for the variables utilized in the present analyses. The findings suggest a statistically significant positive correlation between age and mental health at T0. Moreover, gender had a significant positive correlation with the work ability and mental health at T0 and T1. The positive correlation of gender indicated that men exhibited higher scores than women across these variables. Age and gender showed no significant correlation.

**Table 1** Means and standard deviations for work ability, physical health, and mental health

| | | | Work Ability | | Physical Health | | Mental Health | |
|---|---|---|---|---|---|---|---|---|
| | **Group** | **N** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| T0 | IG | 98 | 34.7 | 6.5 | 47.8 | 8.9 | 45.2 | 11.8 |
| | CG | 75 | 34.2 | 7.1 | 46.2 | 9.6 | 42.8 | 11.4 |
| | Total | 173 | 34.5 | 6.8 | 47.1 | 9.2 | 44.1 | 11.7 |
| T1 | IG | 98 | 36.1 | 6.6 | 46.6 | 9.0 | 48.6 | 10.3 |
| | CG | 75 | 35.7 | 7.4 | 46.7 | 10.9 | 45.8 | 10.9 |
| | Total | 173 | 35.9 | 6.9 | 46.6 | 9.9 | 47.4 | 10.6 |
| T2 | IG | 98 | 35.8 | 7.5 | 47.1 | 9.2 | 48.7 | 10.4 |
| | CG | 75 | 35.0 | 8.5 | 45.3 | 10.6 | 46.9 | 10.6 |
| | Total | 173 | 35.5 | 8.0 | 46.3 | 9.8 | 47.9 | 10.5 |

*IG* Intervention Group, *CG* Control Group, *SD* Standard Deviation

**Table 2** Correlation matrix

| | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
|---|---|---|---|---|---|---|---|---|---|---|
| Age (1) | .00 | -.14 | -.19 | .21* | -.20 | -.16 | .05 | -.09 | -.11 | .04 |
| Gender (2) | | .21* | .05 | .26* | .23* | .15 | .21* | .17 | .13 | .15 |
| WAI T0 (3) | | | .47* | .54* | .70* | .36* | .43* | .67* | .32* | .49* |
| Phys Health T0 (4) | | | | -.13 | .48* | .67* | .02 | .43* | .44* | .20 |
| Ment Health T0 (5) | | | | | .37* | .01 | .61* | .35* | .09 | .55* |
| WAI T1 (6) | | | | | | .52* | .54* | .80* | .42* | .51* |
| Phys Health T1 (7) | | | | | | | -.06 | .48* | .58* | .20 |
| Ment Health T1 (8) | | | | | | | | .47* | .11 | .64* |
| WAI T2 (9) | | | | | | | | | .58* | .60* |
| Phys Health T2 (10) | | | | | | | | | | .11 |
| Ment Health T2 (11) | | | | | | | | | | |

*WAI* Work Ability Index, *Phys Health* Physical Health, *Ment Health* Mental Health

* Bonferroni-Holm adjusted for $p < .05$

### Analyses of variance

The results of the analysis of variance demonstrated significant time effects on work ability, which comprises both linear ($\eta^2 = 0.03$) and quadratic ($\eta^2 = 0.06$) components (see Table 3). In contrast, the interaction between time and group was not significant in neither the linear nor the quadratic trend. Figure 1a depicts the mean trend across the measurement time points for both groups. It is observed that there was a relatively steep increase in WAI for both groups from T0 to T1, followed by a slight decrease in WAI scores from T1 to T2.

Regarding physical health, the time effect and the interaction between time and group did not show any linear or quadratic trend. The development of physical health in both groups is shown in Fig. 1b. Concerning mental health, a significant time effect was observed, comprising both a linear ($\eta^2 = 0.12$) and a quadratic ($\eta^2 = 0.03$) trend. Figure 1c demonstrates a very steep increase from T0 to T1 and a somewhat flattened increase from T1 to T2. The interaction effect between time and group did not show any significant linear or quadratic trend.

### Analyses of variance with age and gender

In the statistical analysis of work ability, age was included as a covariate and gender as an additional factor. The results of the analysis of variance showed that none of the independent variables had a significant effect on work ability. In addition, the effect of time on work ability was not significant in neither the linear nor the quadratic trend (see Table 4). For physical health, the same pattern emerged, as no significant effect was observed for any of the independent variables. Conversely, for mental health, a significant effect was observed only for time in the linear trends.

**Table 3** Analyses of variances for work ability, physical health, and mental health

| **Work Ability** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Trend** | **SS** | **df** | **MSS** | **F** | **P** | **$\eta^2$** |
| T | Linear | 82.7 | 1 | 82.7 | 4.5 | .04 | .03 |
| | Square | 11.5 | 1 | 11.5 | 1.2 | < .01 | .06 |
| T * Gr | Linear | 1.8 | 1 | 1.8 | 0.1 | .75 | .00 |
| | Square | 3.1 | 1 | 3.1 | 0.3 | .59 | .00 |
| Error | Linear | 3139.7 | 171 | 18.4 | | | |
| | Square | 1849.7 | 171 | 1.8 | | | |
| Physical Health | | | | | | | |
| T | Linear | 46.2 | 1 | 46.2 | 1.0 | .33 | .01 |
| | Square | 0.1 | 1 | .1 | 0.0 | .95 | .00 |
| T * Gr | Linear | 1.4 | 1 | 1.4 | 0.0 | .87 | .00 |
| | Square | 94.2 | 1 | 94.2 | 3.0 | .08 | .02 |
| Error | Linear | 8284.4 | 173 | 47.9 | | | |
| | Square | 5405.2 | 173 | 31.2 | | | |
| Mental Health | | | | | | | |
| T | Linear | 1257.3 | 1 | 1257.3 | 24.1 | < .01 | .12 |
| | Square | 186.4 | 1 | 186.4 | 4.5 | .04 | .03 |
| T * Gr | Linear | 9.5 | 1 | 9.5 | 0.2 | .67 | .00 |
| | Square | 17.1 | 1 | 17.1 | 0.4 | .52 | .00 |
| Error | Linear | 9012.7 | 173 | 52.1 | | | |
| | Square | 7139.6 | 173 | 41.3 | | | |

*WAI* Work Ability Index, *Phys Health* Physical Health, *Psych Health* Mental Health, *SS* Sum of Squares, *MSS* Mean Sum of Squares, *df* degrees of freedom, *T* Time, *Gr* Group

* $p < .05$

### Interaction between time, group and age

A repeated-measures analysis of variance was conducted to investigate the three-way interaction among time, group, and age, with age being dichotomized. The results revealed a significant three-way interaction effect for the linear trend in mental health ($F = 5.3$; $df_1 = 1$; $df_2 = 165$; $p < 0.05$; $\eta^2 = 0.03$) and the quadratic trend in work ability ($F = 7.5$; $df_1 = 1$; $df_2 = 165$; $p < 0.05$; $\eta^2 = 0.04$), but not for physical health ($F = 2.7$; $df_1 = 1$; $df_2 = 167$; $p < 0.05$; $\eta^2 = 0.00$). Specifically, younger participants displayed a significant improvement in the intervention group for both work ability (Fig. 2a) and mental health (Fig. 2b), whereas older participants demonstrated a greater improvement in the control group for both work ability (Fig. 2c) and mental health (Fig. 2d).

## Discussion

The promotion of employees' well-being and productivity is crucial for our society as well as organizations, pointing to the need of research on interventions that can enhance work ability, physical health, and mental health [25, 26]. With technological advancements, digital prevention interventions have become accessible to large segments of the population who may not have access to conventional prevention services [27]. This study aimed to compare the effectiveness of a digital prevention intervention with a conventional prevention program, BETSI/RV Fit, regarding work ability, physical health, and mental health in professionals experiencing initial impairments, as well as to examine the role of age and gender on the effectiveness of the interventions.

The findings of this study suggest that both digital and conventional prevention programs had an effect on work ability. This is in line with previous research that has shown that digital interventions can lead to improvements in work ability [28]. The initial steep increase in work ability in both groups during the first 12 weeks of the intervention is also consistent with previous studies that have reported rapid improvements in work ability following workplace interventions [29]. The deceleration in the rate of enhancement of work ability, especially among the control group, over the ensuing 12-week period is consistent with earlier observations, indicating that continued interventions and aid may be necessary to sustain improvements in work ability. The standard regimen of Betsi/RV Fit incorporates a self-directed training phase in the latter half of the program, which may not offer an equivalent degree of direction and assistance as the supervised

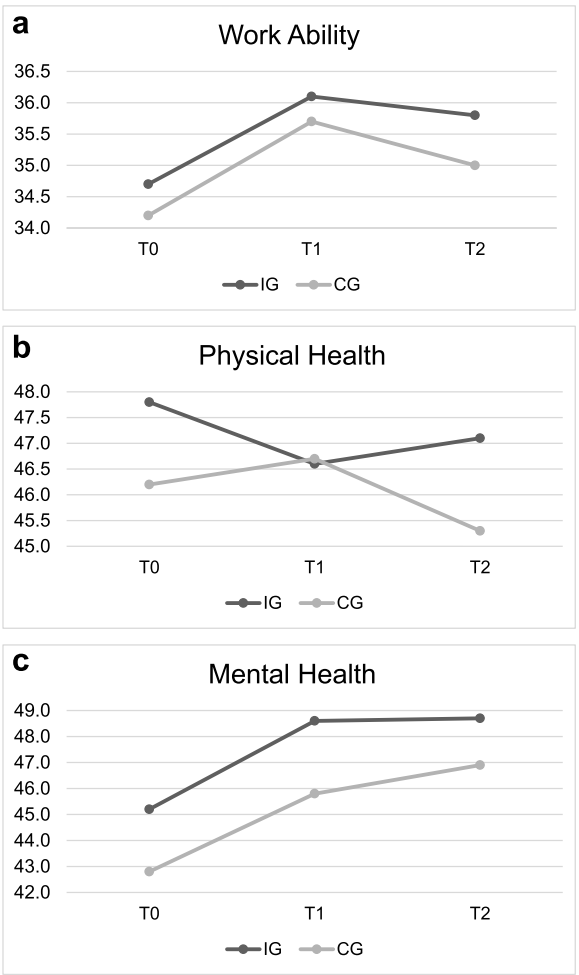


**Fig. 1** Mean value progression over the three measurement points for work ability, physical health, and mental health

program during the initial 12 weeks. These findings are in accordance with previous research, which suggests that enduring advancements in work capacity may require ongoing support and intervention [30]. The age-specific effects found in this study are also consistent with previous research, suggesting that age can influence the effectiveness of workplace interventions on work ability [31].

The present study did not find a significant effect for either time, group, or interaction on physical health, even when age and gender were included in the analyses. These results suggest that the effects of preventive interventions, whether digital or conventional, may require more time to develop an impact on physical health. Therefore, longer-term interventions and observations may be necessary to uncover any potential effects on physical health. This finding is consistent with previous research that has highlighted the importance of long-term interventions in improving physical health outcomes [32]. Moreover, it has been suggested that digital interventions may have the potential to improve physical health outcomes over a longer period of time [33]. Nonetheless, more research is needed to determine the long-term effects of preventive interventions on physical health.

For mental health, the results of the present study revealed a significant time effect in the form of both a linear and a quadratic trend. Specifically, there was an initial steep increase in mental health during the first 12 weeks of the prevention programs, followed by a slower increase in the second half of the programs. These findings suggest that the first 12 weeks of the interventions are crucial for achieving significant improvements in mental health. For the control group, this suggests that there is a slower improvement in mental health after the end of personal assistance in the training phase and with the beginning of the self-initiation phase. Interestingly, this slowdown also occurs in the intervention group. A separate study would be needed to explain this phenomenon. Moreover, the linear trend remained significant even when age and gender were included in the analysis of variance. This finding is consistent with prior research suggesting a linear relationship between the duration of interventions and mental health outcomes [34].

The present study's findings demonstrated that the effects of digital and conventional prevention interventions on work ability and mental health were moderated by age. Specifically, younger participants exhibited a greater improvement in work ability and mental health following the digital prevention intervention, while older participants benefited more from the conventional prevention intervention. These findings are in line with prior research that has identified age as a significant factor influencing the efficacy of digital interventions for mental health [35]. It is possible that older adults may experience more barriers to using mobile-based mental health interventions, such as concerns about technology literacy, privacy, and security, and may prefer more conventional, face-to-face interventions [36]. Conversely, younger adults may be more comfortable and familiar with digital technology and therefore may benefit more from digital interventions. Nonetheless, these findings highlight the importance of tailoring interventions to different age groups in order to maximize their effectiveness and reach. Future studies could explore how to further adapt digital interventions to meet the unique needs and preferences of older adults as well as how to overcome potential barriers to their use.

The present study provides valuable insights into the effectiveness of a digital and conventional prevention program on work ability, physical health, and mental health outcomes. However, there are limitations to consider. Firstly, the quasi-experimental design of the study

**Table 4** Analyses of variances for work ability, physical health, and mental health, including age and gender

| **Work Ability** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Trend** | **SS** | **df** | **MSS** | **F** | **P** | $\eta^2$ |
| Time | Linear | 0.5 | 1 | 0.5 | 0.0 | 0.87 | 0.00 |
| | Square | 31.6 | 1 | 31.6 | 3.0 | 0.09 | 0.02 |
| Time * Age | Linear | 3.8 | 1 | 3.8 | 0.2 | 0.65 | 0.00 |
| | Square | 15.0 | 1 | 15.0 | 1.4 | 0.24 | 0.01 |
| Time * Group | Linear | 3.4 | 1 | 3.4 | 0.2 | 0.67 | 0.00 |
| | Square | 0.6 | 1 | 0.6 | 0.1 | 0.81 | 0.00 |
| Time * Gender | Linear | 3.3 | 1 | 3.3 | 0.2 | 0.68 | 0.00 |
| | Square | 17.6 | 1 | 17.6 | 1.6 | 0.20 | 0.01 |
| T * Gr * Ge | Linear | 1.3 | 1 | 1.3 | 0.1 | 0.79 | 0.00 |
| | Square | 9.3 | 1 | 9.3 | 0.9 | 0.35 | 0.01 |
| Error | Linear | 3132.1 | 168 | 18.6 | | | |
| | Square | 1798.4 | 168 | 10.7 | | | |
| Physical Health | | | | | | | |
| Time | Linear | 23.3 | 1 | 23.3 | 0.5 | 0.49 | 0.00 |
| | Square | 0.5 | 1 | 0.5 | 0.0 | 0.90 | 0.00 |
| Time * Age | Linear | 19.0 | 1 | 19.0 | 0.4 | 0.53 | 0.00 |
| | Square | 1.0 | 1 | 1.0 | 0.0 | 0.86 | 0.00 |
| Time * Group | Linear | 1.3 | 1 | 1.3 | 0.0 | 0.87 | 0.00 |
| | Square | 32.1 | 1 | 32.1 | 1.0 | 0.31 | 0.01 |
| Time * Gender | Linear | 35.5 | 1 | 35.5 | 0.7 | 0.39 | 0.00 |
| | Square | 26.5 | 1 | 26.5 | 0.8 | 0.36 | 0.01 |
| T * Gr * Ge | Linear | 9.9 | 1 | 9.9 | 0.2 | 0.65 | 0.00 |
| | Square | 85.2 | 1 | 85.2 | 2.7 | 0.10 | 0.02 |
| Error | Linear | 8181.9 | 168 | 48.7 | | | |
| | Square | 5263.8 | 168 | 31.3 | | | |
| Mental Health | | | | | | | |
| T | Linear | 325.0 | 1 | 325.0 | 6.3 | 0.01 | 0.04 |
| | Square | 97.8 | 1 | 97.8 | 2.3 | 0.13 | 0.01 |
| T * Age | Linear | 183.7 | 1 | 183.7 | 3.5 | 0.06 | 0.02 |
| | Square | 64.7 | 1 | 64.7 | 1.5 | 0.22 | 0.01 |
| T * Gr | Linear | 11.7 | 1 | 11.7 | 0.2 | 0.64 | 0.00 |
| | Square | 14.4 | 1 | 14.4 | 0.3 | 0.56 | 0.00 |
| T * Ge | Linear | 95.2 | 1 | 95.2 | 1.8 | 0.18 | 0.01 |
| | Square | 1.9 | 1 | 1.9 | 0.0 | 0.83 | 0.00 |
| T * Gr * Ge | Linear | 12.2 | 1 | 12.2 | 0.2 | 0.63 | 0.00 |
| | Square | 1.0 | 1 | 1.0 | 0.0 | 0.88 | 0.00 |
| Error | Linear | 8696.5 | 168 | 51.8 | | | |
| | Square | 7060.7 | 168 | 42.0 | | | |

*SS* Sum of Squares, *MSS* Mean Sum of Squares, *df* degrees of freedom, *T* Time, *Gr* Group, *Ge* Gender

* $p < .05$

may limit its generalizability. A randomized controlled trial would have been more appropriate to test the effectiveness of the prevention program rigorously. Secondly, the absence of a control group without any prevention program may have allowed unknown factors to influence the interventions' effects, and therefore, the effects cannot be solely attributed to the interventions. Thirdly, the small sample size may have impacted the study's statistical power. Increasing the sample size would have allowed for greater precision in estimating the effects of the prevention programs. Forthly, a notable limitation of this study is the dropout rate of approximately

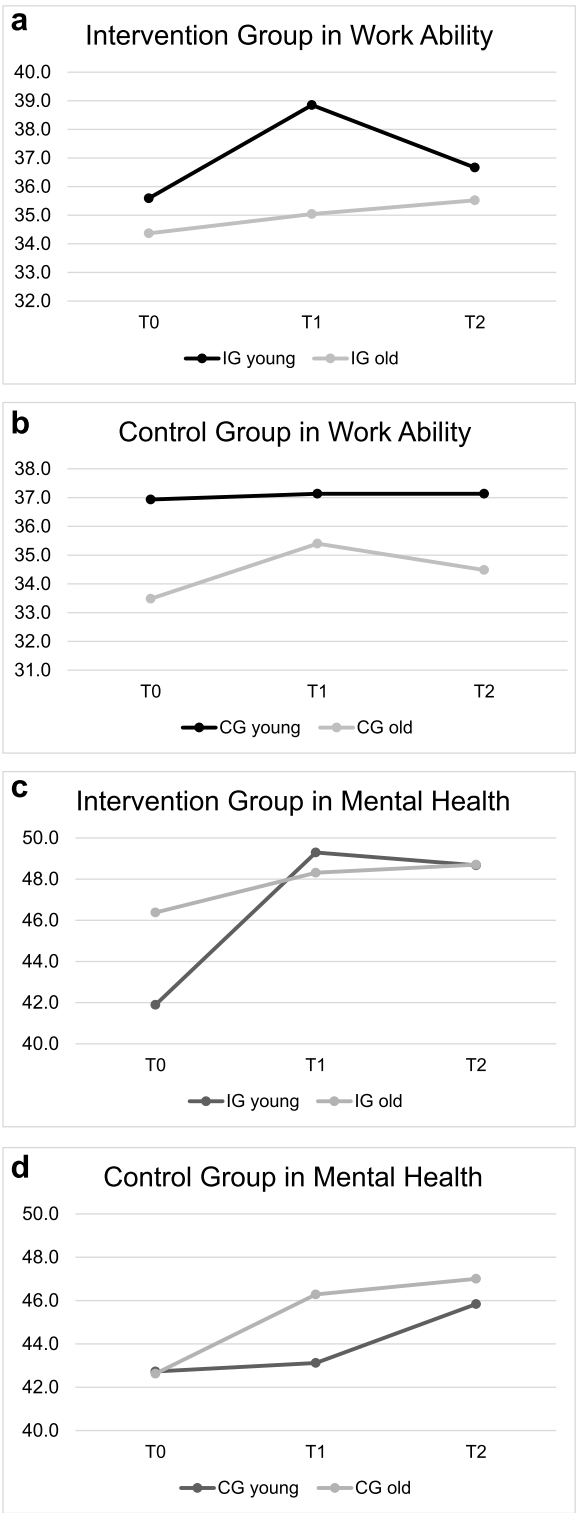


**Fig. 2** Mean work ability / mental health progression for younger and older participants in both groups

30%, which, although found to be non-systematic, leaves unanswered questions about the underlying reasons for participant withdrawal. This absence of detailed insight into the causes of dropout impacts the generalizability of the findings and indicates area need for qualitative research to better understand and reduce potential barriers for participation. Lastly, the lack of follow-up assessments is an important limitation, as it is unclear whether the improvements in work ability and mental health observed during the intervention phase would persist over time. Future research should conduct long-term follow-up assessments to determine the sustainability of the prevention program's effects.

This study on the effectiveness of digital and conventional prevention programs has important implications for both research and practice. For research, the study highlights the importance of utilizing rigorous research designs, such as randomized controlled trials, and increasing sample sizes to improve the validity and generalizability of study findings. Future research should also incorporate follow-up assessments to examine the sustainability of intervention effects over time. For practice, the study suggests that both digital and conventional prevention programs can be effective in improving work ability and mental health. However, it is important for practitioners to carefully consider the characteristics of their target population and to select the most appropriate prevention program for their needs. The findings indicate that a digital intervention shows particular promise for younger individuals, while older individuals are more likely to benefit from conventional interventions. Nonetheless, it is possible that age-specific effects will diminish as older populations become more accustomed to digital technologies.

## Conclusions

The results of the study suggest that prevention programs, both digital and conventional, have the potential to improve work ability and mental health outcomes. This improvement is particularly evident in the early stages of the intervention. The study highlights the importance of taking age-specific factors into account when designing and implementing these programs. However, the study's limitations, such as the small sample size, quasi-experimental design, and lack of follow-up assessments, must be recognized. Future research addressing these limitations could provide a more comprehensive understanding of the effectiveness of prevention programs in promoting work ability and physical and mental health outcomes. In summary, this study provides useful insights into the effectiveness of prevention programs and emphasizes the need for further research.

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**Authors' contributions**
DS contributed to the conceptualization, data analysis, writing of the original draft, and acquisition of funding. JF contributed to the organization, conduct, data preparation, and revision of the original draft. KF and SW contributed to the revision of the original draft. DJ contributed to the conceptualization, planning, coordination, assistance with data analysis, and supervising of the writing and revision of the manuscript.

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**Availability of data and materials**
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Ethics approval and consent to participate**
The present study was carried out in compliance with the principles outlined in the Declaration of Helsinki. Participants provided informed consent on a voluntary basis and could withdraw from the study at any time without providing a reason and without experiencing any negative consequences in terms of their subsequent medical care. Participants' consent was recorded via their signature on the informed consent forms. The Ethics Committee of the Karlsruhe Institute of Technology (328–18-1200) granted approval for the study on March 20, 2019, including all participants, conditions, and health centers involved in the project.

**Consent for publication**
Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

**Competing interests**
The authors declare no competing interests.

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## Publisher's Note