

# BMJ Open Video-based smartphone app ('VIDEA bewegt') for physical activity support in German adults: a single-armed observational study

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## ABSTRACT

**Objectives** The primary objective of this study was to investigate the effect of the video-based smartphone app 'VIDEA bewegt' over eight programme weeks on physical activity in German adults.

**Design** The study used a single-arm observational design, assessing the app's effectiveness under real-life conditions. Data were collected from July 2019 to July 2020.

**Setting** The app is enabling users to access video-based educational content via their smartphone. A clinical visit or in-person contact was not required.

**Participants** All individuals registered in the freely available app were invited to take part in the study.

**Interventions** The app aims to increase physical activity in everyday life. It combines educative videos on lifestyle-related benefits and instructional videos of strength and endurance exercises to do at home with motivational components like goal setting, documentation of progress and personalised messages.

**Primary and secondary outcome measures** Primary outcomes were physical activity based one MET minutes per week (metabolic equivalent) and step numbers. Secondary outcomes included physical self-efficacy (motivational, maintenance, recovery self-efficacy), health-related quality of life: Mental Health Component Summary score and Physical Health Component Summary score.

**Results** Of 97 people included in the data analysis, 55 successfully completed the programme and all questionnaires. Significant increases over eight programme weeks (between T0 and T2) were observed in physical activity based on MET minutes per week, health-related quality of life, and recovery self-efficacy. Time spent sitting and body mass index significantly decreased for those completing the programme.

**Conclusions** Although significant benefits of physical activity were observed following a complete-case analysis, results should be dealt with caution. Studies with a larger and less heterogeneous sample and robust study designs able to measure causal effects would be desirable.

**Trial registration number** DRKS00017392.

## INTRODUCTION

### Background

Non-communicable diseases are substantially caused by lifestyle-associated factors

## Strengths and limitations of this study

- The evaluation of the intervention is carried out under real-life conditions.
- Various approaches were used to describe the effects of the intervention.
- The small sample size, broad inclusion criteria for participation bias and a high drop-out rate limit the internal validity.
- Due to its observational design and the absence of a control group and randomisation, this study can only provide limited data on how individual app components contributed to the overall effect of the app.
- Most data collected were based on self-assessment.

like insufficient physical activity.<sup>1</sup> In addition to non-communicable diseases, activity also influences quality of life and mental health.<sup>2</sup> To prevent chronic diseases like diabetes, it is recommended to promote physical activity across all age groups.<sup>3–6</sup> Effective strategies to increase motivation and reduce barriers for behavioural change require sustained efforts and ongoing support.<sup>7–9</sup> Behavioural change support by the use of smartphones in particular seems promising due to their widespread use and low barriers to participation uptake.<sup>10 11</sup>

Smartphone app-based interventions providing performance-related feedback, psychosocial networking and goal setting have been found to effectively increase physical activity.<sup>12–16</sup>

Furthermore, it has been widely described that increased self-efficacy can have positive effects on behavioural change.<sup>17–19</sup> According to the Health Action Process Approach (HAPA), different subcomponents of self-efficacy can be distinguished.<sup>20</sup> Particularly decisive is the stability respectively variability of the subcomponents in this study. Digital interventions have the unique potential to

combine these effective strategies while keeping user acceptance high.<sup>21 22</sup>

Despite these known components of successful behavioural change, the generation of evidence in the field of digitally supported behavioural change predominantly focused on apps developed in relation to scientific studies, rather than evaluating freely accessible apps.<sup>23 24</sup> As a result, despite the increasing number of health apps on the market, the minority of them is based on strong empirical and scientific evidence.<sup>10 25–28</sup> Scientific evaluations of available apps offer great potential for improving both present and future apps.<sup>29–31</sup> While studies show promising results on the effectiveness of these interventions to prevent<sup>32</sup> or successfully manage<sup>6 33</sup> chronic lifestyle-related diseases, for example, by using videos for preventive purposes,<sup>34</sup> the strategies needed to achieve sustainable behavioural change seem to have received little attention.<sup>12</sup>

Reasons for the described limited evidence base of digital health apps include methodological challenges during evaluation. In order to guide evidence-based decision making, randomised controlled trials (RCTs) are regarded as highest level.<sup>35</sup> However, digital health interventions usually comprise multiple components and are mostly designed as modular interventions offering tailored as well as performance-based adaptations or feedback.<sup>36</sup> This may end up in circumstances where RCTs may not be feasible. As such, challenges including randomisation, timing of assessment, acceptance by patients and physicians, blinding, as well as defining control groups and relevant endpoints need to be considered.<sup>37</sup> In addition to the described challenges during evaluation, limited guidance is available on the mid-term to long-term outcomes.<sup>38 39</sup>

Therefore, the primary objective of this study was to investigate the effect of the video based and freely on the market available smartphone app ('VIDEA bewegt') over eight programme weeks on physical activity (metabolic equivalent, MET minutes per Week and steps per day) in German adults. Secondary objectives were to analyse the associated changes in self-efficacy and health-related quality of life.

### Hypotheses

The users of 'VIDEA bewegt' who participate in the study increase their average daily step count and achieve a higher number of MET minutes per week, a significantly higher health-related quality of life, a significantly higher motivational, maintenance and recovery self-efficacy after the first 4 weeks, and after completion of the 8 weeks course, compared with the beginning of data collection.

## MATERIALS AND METHODS

A detailed study protocol following important recommendations formulated by Eysenbach and the Consolidated Standards of Reporting Trials-EHEALTH Group<sup>40</sup> was published prior to the data analysis.<sup>41</sup>

## Study design and summary of intervention

Data collection took place from July 2019 to July 2020. The evaluation of the app 'VIDEA bewegt' is designed as a single-arm observational study, assessing the app's effectiveness and usability under real-life conditions. The smartphone app 'VIDEA bewegt' is a video-based programme to increase physical activity in everyday life. The app is divided into eight programme weeks, each of which follows a consistent structure. The core of the app are four videos per programme week. Theoretical videos explain and illustrate the importance of exercise and lifestyle, as well as ways to build up motivation. Practical videos present exercises to improve strength and endurance in a way which can be followed without the use of supplies. Additionally, motivational components such as goal setting, progress documentation and personal messages are included. More extensive information can be found in the study protocol.<sup>41</sup>

### Setting

'VIDEA bewegt' is an app enabling users to access educational content via their smartphone anywhere and at any time. It was made available on the German market for Android and iOS in March 2019. Costs of the programme are partially reimbursed by health insurance companies. Further information can be found on the German website <https://videabewegt.de>.<sup>42</sup>

A clinical visit or in-person contact with a physician or diabetes specialist was not required. However, it was possible to consult experts in preventative healthcare and sports science via an integrated chat function. Problems could also be discussed with other users and experts in a forum.

### Participants

To register in the app, interested individuals had to be of legal age ( $\geq 18$  years old) and declare that they were free of serious medical conditions such as heart failure. All registered individuals were invited to the study without further restriction.

### Patient and public involvement

Potential participants were included in pretesting the questionnaires in order to assess their logic, understandability and technical performance. A usability test with 10 individuals provided insight in strengths and weaknesses of the app. Additionally, all study participants were asked to answer questions regarding their experience with the app's components. All data that made it possible to further optimise the app was forwarded to the developing company.

### Procedure

App users interested in the study received an email and access to the first online questionnaire, which included the consent form and privacy policy. Individuals who completed the first questionnaire became study participants and received further questionnaires after completion of the fourth and eighth programme weeks. In

addition, internal app usage data including step counts were collected. For the analysis, three relevant time points were defined at which the individual outcome variables would be compared. The programme start defined the time point T0, the programme half the time point T1 and the programme completion the time point T2. Participants received an email with a link to the online questionnaire at each time point. As such, data collection depended on participants' programme usage. If a questionnaire was not completed after 2 days, the participants received a reminder. The study was conducted entirely digitally.

### Outcomes

Primary outcomes were physical activity based on MET minutes per week and step numbers.

Secondary outcomes included physical self-efficacy (motivational, maintenance, recovery self-efficacy), health-related quality of life: MCS (Mental Health Component Summary score) and PCS (Physical Health Component Summary score).

To measure the outcome variables, validated self-reporting measurement instruments were applied. The Global Physical Activity Questionnaire (GPAQ) was used to record MET minutes per week as well as sedentary time per day.<sup>43 44</sup> The assessment of health-related quality of life is based on the SF-8 questionnaire.<sup>45 46</sup> Self-efficacy was measured in the three dimensions of motivation self-efficacy, maintenance self-efficacy and recovery self-efficacy.<sup>47 48</sup> For each of these three dimensions, statements were phrased in a questionnaire to which agreement was indicated using a Likert scale. Objective measurements of step counts were used. As a source of these step counts, users could either synchronise an external pedometer with the app or capture steps with their smartphone. For the comparison between T0 and T2, all persons were included who had entered their steps on at least 5 of 14 days at both start and end of the programme. For the comparison between T0 and T1, all persons who had entered their steps on at least 3 of 7 days were included.

### Statistical analyses

Sociodemographic data and user behaviour were analysed descriptively. The Shapiro-Wilk test was used to test for normal distribution. The hypotheses were tested using a one-sided Wilcoxon test for dependent samples at T0, T1 and T2 due to lack of normal distribution. A subgroup analysis was not conducted on account of the small sample size. Due to the exploratory nature of the data analysis, Bonferroni correction was omitted.<sup>49 50</sup> Instead, an exploratory analysis was added to separate individuals who completed the programme and who showed an increase in activity.

Average values were calculated for the number of steps per day. For the comparison of T0 and T2, all persons were included who synchronised steps on at least 5 of 14 days at the beginning and end. For the comparison of T0 and T1,

persons with at least three out of 7 days of synchronisation were included following the same method.

The analysis was conducted as a complete case analysis.

## RESULTS

### Description of the sample

During the data collection period, 1519 individuals registered with the app. Of those, 103 individuals (6,8%) followed the study invitation and completed the first questionnaire. Two people withdrew their participation during the survey, and four people were excluded from the analysis because of not completing the first questionnaire at the beginning of programme use. Consequently, 97 people were included in the data analysis, 55 of whom successfully completed the programme and all questionnaires (see [table 1](#)).

The median duration of programme use was 68 days (IQR 64 days). The female participants accounted for 82% of the participants.

### Comparison of persons with and without programme completion

A total of 42 out of 97 study participants had not completed the programme, which resulted in 42 (43%) incomplete datasets. Due to the proportion of missing data exceeding 40%, imputation methods were not used.<sup>51</sup>

Comparing the groups of persons with and without programme completion, age, gender distribution and marital status did not differ substantially. In the group with programme completion, the proportion of persons with a university degree was larger. The proportion of full-time employees was smaller resulting in a larger proportion of retired persons. In the group with programme completion, the proportion of people who used additional health apps was smaller. Body mass index (BMI) was also lower here, while health-related quality of life and physical activity did not differ.

### Physical activity

The hypothesis that physical activity increases significantly between programme start and completion can be supported for self-reported MET minutes per week. In contrast, the hypothesis that there is a significant increase in MET minutes already within the first half of the programme cannot be confirmed (see [table 2](#)). For the number of steps per day, neither a significant increase in the first half nor over the entire programme time was detected.

### Health-related quality of life and self-efficacy

The hypotheses that health-related quality of life based on the PCS and the MCS increases significantly in the first half of the programme and over the entire programme period can both be confirmed. Looking at self-efficacy, the formulated hypotheses can only be confirmed for recovery self-efficacy, where there was a significant increase over the entire programme period. In contrast,

**Table 1** Characteristics of the study population

Overall N	97
Age mean (SD) in years	47.52 (13.52)
Sex	80 female (82%), 17 male (18%)
Body mass index median (IQR) in kg/m*	26.26 (8.8)
Marital status	
Married	57
Living in stable relationship	15
Divorced, separated	10
Single	11
Widowed	3
Other	1
Level of education	
Completed professional training	32
Degree from university	35
High school	14
Secondary school	13
Other	4
Gainful employment	
Full-time	49
Half-time	16
Retired	16
Part-time employed	7
Not employed	9
Other sports courses†	
Yes	49
No	48
Other health apps*	
Yes	30
No	67

\*Use of other health apps in addition to the VIDEA programme.

†Participation in sports courses

VIDEA, video-based smartphone app.

there were no significant increases in motivational and maintenance self-efficacy (see [table 3](#)).

### Additional analysis

In addition, to the main hypotheses described above, further calculations were performed using the data from the GPAQ and the general questionnaire.

In a first analysis, using only programme completers with complete data sets (n=55), the body mass index (BMI) was analysed, which decreased significantly over the entire programme period and between T1 and T2. Furthermore, the time participants spend sitting per day decreased significantly between T0 and T2 as well as T1 and T2. In addition to calculating MET minutes per week, the GPAQ also allows for an analysis of separate activity dimensions (work, transportation, and leisure). The analysis showed that activity during leisure time increased significantly, while activity at work and in transportation did not change significantly (see [table 4](#)).

Because a large proportion of participants already reported high values of MET minutes per week (>4000 MET minutes per week) at T0 and were thus less likely to benefit from further increases in activity,<sup>52</sup> the comparison between T0 and T2 was repeated for all individuals with baseline activity of less than 4000 MET minutes per week. Results indicate a significant increase in activity for these participants with large effect sizes (see [table 4](#)).

### DISCUSSION

The primary aim of this study was to assess the effects of the video-based smartphone app 'VIDEA bewegt' on physical activity and related outcomes in German adults under real-life conditions. Individuals who completed the programme experienced a significant increase in physical activity based on several parameters and health-related quality of life. Furthermore, the recovery self-efficacy increased significantly as well.

Data were collected from 97 study participants to provide the basis for the conducted study. Women accounted for more than three-quarters of the sample. It is known that women tend to be more interested in health

**Table 2** Primary outcome measures, using asymptomatic one-sided Wilcoxon-tests

	Median (IQR) n=55	T0 vs T1	T1 vs T2	T0 vs T2
MET minutes per week	T0: 2400 (3140) T1: 2760 (4100) T2: 2640 (5680)	z=-1.391, p=0.082, n=55, r=0.188	z=-1.778, p=0.038, n=55, r=0.240	z=-1.927, p=0.027, n=55, r=0.260
Steps per day	T0: 7043 (4347), n=27 T2: 6829 (4878), n=27	z=-0.470, p=0.638, n=31, r=0.084		z=-1.562, p=0.061, n=27, r=0.301

MET, metabolic equivalent; T0, programme start; T1, programme half; T2, programme completion.

**Table 3** Primary outcome measures, using asymptomatic one-sided Wilcoxon tests

	Median (IQR) n=55	T0 vs T1	T1 vs T2	T0 vs T2
PCS	T0: 49.74 (13.06) T1: 51.80 (13.34) T2: 50.14 (9.33)	$z=-2.409$ , $p=0.008$ , $n=55$ , $r=0.325$	$z=-1.694$ , $p=0.045$ , $n=55$ , $r=0.228$	$z=-3.050$ , $p=0.001$ , $n=55$ , $r=0.411$
MCS	T0: 47.80 (12.17) T1: 52.49 (8.09) T2: 52.31 (9.56)	$z=-3.599$ , $p<0.001$ $n=55$ , $r=0.485$	$z=-0.537$ , $p=0.296$ , $n=55$ , $r=0.072$	$z=-3.484$ , $p<0.001$ , $n=55$ , $r=0.470$
Motivational self-efficacy	T0: 3.67 (1.00) T1: 3.67 (1.16) T2: 3.67 (1.66)	$z=-0.528$ , $p=0.238$ , $n=55$ , $r=0.071$	$z=-0.421$ , $p=0.737$ , $n=55$ , $r=0.057$	$z=-0.125$ , $p=0.574$ , $n=55$ , $r=0.017$
Maintenance self-efficacy	T0: 3.00 (1.00) T1: 3.00 (1.00) T2: 3.33 (1.33)	$z=-1.043$ , $p=0.142$ , $n=55$ , $r=0.141$	$z=-0.592$ , $p=0.289$ , $n=55$ , $r=0.08$	$z=-1.199$ , $p=0.092$ , $n=55$ , $r=0.162$
Recovery self-efficacy	T0: 3.00 (0.84) T1: 3.67 (1.00) T2: 4.00 (2.00)	$z=-0.368$ , $p=0.323$ , $n=55$ , $r=0.05$	$z=-2.075$ , $p=0.019$ , $n=55$ , $r=0.28$	$z=-1.850$ , $p=0.032$ , $n=55$ , $r=0.249$

MCS, Mental Component Summary Score; PCS, Physical Component Summary Score; T0, programme start (baseline); T1, programme half; T2, programme completion.

interventions than men and are easier to convince of new interventions.<sup>53 54</sup> Additionally, well-educated people often have a greater interest in health interventions. It is therefore not surprising that the study mainly involved

people who had completed their education and were in full-time employment.<sup>54</sup>

Effectiveness: The 55 subjects with programme completion reported a median physical activity of 2400 MET

**Table 4** Additional analyses using asymptomatic two-sided Wilcoxon tests

	Median (IQR)	T0 vs T1	T1 vs T2	T0 vs T2
BMI in kg/m <sup>2</sup> , n=55	T0: 25.51 (8.45) T1: 25.95 (8.54) T2: 24.91 (7.26)	$z=-0.010$ , $p=0.992$ , $r=0.001$	$z=-3.117$ , $p=0.002$ , $r=0.420$	$z=-2.445$ , $p=0.014$ , $r=0.330$
Time spent sitting in hours, n=55	T0: 6 (4) T1: 6 (4) T2: 5 (4)	$z=-0.420$ , $p=0.675$ , $r=0.091$	$z=-2.962$ , $p=0.003$ , $r=0.399$	$z=-2.472$ , $p=0.013$ , $r=0.333$
Active minutes in leisure time in minutes per day, n=55	T0: 25.71 (22.86) T1: 27.31 (30.00) T2: 31.43 (51.43)	$z=-3.053$ , $p=0.002$ , $r=0.412$	$z=-1.171$ , $p=0.242$ , $r=0.158$	$z=-2.898$ , $p=0.004$ , $r=0.391$
Active minutes at work, in minutes per day, n=55	T0: 12.86 (64.29) T1: 21.43 (85.71) T2: 14.29 (100.00)	$z=-0.314$ , $p=0.753$ , $r=0.042$	$z=-0.403$ , $p=0.687$ , $r=0.054$	$z=-1.559$ , $p=0.119$ , $r=0.210$
Active minutes in transport, in minutes per day, n=55	T0: 21.43 (40.00) T1: 21.43 (24.29) T2: 17.14 (31.43)	$z=-0.669$ , $p=0.503$ , $r=0.090$	$z=-1.789$ , $p=0.074$ , $r=0.241$	$z=-0.510$ , $p=0.610$ , $r=0.069$
MET minutes per day of people with initial activity <4000 MET minutes per day, n=41	T0: 1640 (1780) T1: 2560 (2756) T2: 2160 (2510)	$z=-3.882$ , $p<0.001$ , $r=0.606$	$z=-1.109$ , $p=0.267$ , $r=0.173$	$z=-3.039$ , $p=0.002$ , $r=0.475$

BMI, body mass index; MET, metabolic equivalent; T0, programme start; T1, programme half; T2, programme completion.

minutes per week at T0. For people in Germany, a representative study determined an average value of 630 MET minutes per week.<sup>55</sup> Consequently, the sample was physically active to an above-average degree. Insufficient physical activity is defined by the WHO as less than 600 MET minutes per week.<sup>56</sup> However, it is known that physical activity should be much higher in order to effectively reduce risks of chronic diseases.<sup>52</sup> Despite the relatively high baseline physical activity levels of the sample, participants completing the programme showed improvements of physical activity measured by MET minutes per week (significant increase T0/T2 and T1/T2 with  $r=0.260$  and  $r=0.188$ ). Including only those individuals with less than 4000 MET minutes per week at baseline, this increase was significant with medium and strong effect sizes ( $r=0.475$  and  $r=0.606$ ). For this part of the sample, MET minutes per week increased by 32%. Similar rates of activity increase were also found in other studies.<sup>10 15</sup>

Step counts per day are a widely used measure of physical activity.<sup>57</sup> However, only few and incomplete data sets were available in this study, which is why results have to be dealt with caution. The step count data sets did not show any significant increases in the number of steps per day. It would have been desirable to compare the objective step counts with the less objective MET minutes, as recommended.<sup>58</sup> However, since only 27 of 55 people synchronised their steps at the beginning and end of the programme on at least five of 14 days, no such comparison was made.

Sedentary time per day decreased significantly from a median of 6–5 hours. In fact, 5 hours of sedentary time were found to be the average of the German population.<sup>59</sup> While total mortality is significantly reduced by replacing 1 hour of sedentary time with activity,<sup>60</sup> the decrease in sedentary time observed in the study can be interpreted as clinically relevant.

The median BMI of the 97 study participants of 26.26 kg/m<sup>2</sup> at baseline is comparable to similar studies.<sup>10 15 61</sup> It significantly decreased with medium effect size ( $r=0.330$ ) between T0 and T2 for the 55 individuals with programme completion. As such, while the median BMI lied in the range of overweight ( $>25$  kg/m<sup>2</sup><sup>62</sup>) at baseline, participants completing the programme improved to ranges of normal weight ( $<25$  kg/m<sup>2</sup>) after eight programme weeks with individually different time periods being needed (median programme use of 68 days). Considering weight changes as the basis of BMI values, clinically relevant weight decreases of at least 5% were found in 7 of 55 subjects.<sup>63</sup>

Health-related quality of life increased significantly in the first half of the programme, but also over the entire programme period, with a medium effect size. In 2004, norm values of PCS=50.30 and MCS=53.25 were determined for the German population.<sup>64</sup> In the PCS, the number of people above the norm did not change and remained at 27/55. In the MCS, only 12/55 people were above the norm at the beginning of the programme and 25/55 at the end of the programme. Overall, however,

the health-related quality of life could not be rated as above average, since the medians were below the norm at all time points. A clinically relevant change in PCS or MCS of at least three points<sup>65</sup> was found in the PCS for 27/55 subjects and in the MCS for 37/55 subjects.

While motivational and maintenance self-efficacy did not change during the intervention, there was a significant increase in recovery self-efficacy for individuals completing the programme (recovery self-efficacy  $r=0.249$ ). Luszczynska *et al* demonstrated that recovery self-efficacy has a stronger predictive influence on physical activity than maintenance self-efficacy.<sup>66</sup> Based on the HAPA, these findings seem conclusive, as recovery self-efficacy is particularly important for the implementation and execution of new behaviour.<sup>67</sup> The increase of recovery self-efficacy emerged between T1 and T2, while the comparison between T0 and T1 did not show an increase. It is known that recovery self-efficacy is especially important in later stages of behavioural change when barriers and failures occur, with overcoming such setbacks being the main challenge. High recovery self-efficacy also is important for resuming health-promoting behaviours after an interruption.<sup>66</sup> In this study, the rather informal character as well as participants' freedom to execute the whole programme resulted in heterogeneous intervention durations. Thus, individuals who successfully completed the intervention may have been particularly effective at coping with such interruptions. It is possible that the positive learning experiences contributed to an improvement in recovery self-efficacy, as well.

For digital interventions, the correlation of high self-efficacy with high exercise frequency and an increase in health-related parameters is well known.<sup>68</sup> For example, it has already been described that self-efficacy increased during an intervention to reduce BMI.<sup>69</sup> The results of this study confirm the important role of self-efficacy in digital interventions. Accordingly, the specific relevance of each dimension of self-efficacy as well as the maintenance of behavioural changes reflected by mid-to-long-term follow-ups should be addressed in future studies. Research on self-efficacy may help to develop more effective and better individualisable interventions.

Drop-outs: The fraction of people responding to a study invitation is often less than 10%.<sup>70</sup> In this study, 6.8% of the app users became study participants. Of the 97 people included in the analysis, only 55 completed the programme. It is known that loss of interest, hidden costs or complicated use can be responsible for dropout.<sup>71</sup> The sample covered an age range of 22–75 years and had a mean age of 48 years. Similar age averages can also be found in other studies.<sup>10 15 61</sup> An analysis of individual subgroups would have been desirable, but would have required a larger sample.<sup>72</sup>

## Limitations

An important strength of this study is that it was conducted under real-life conditions. Another strength is the user-centred study design, in which potential users

were involved in the design of the questionnaires and the app.<sup>73</sup>

However, the following limitations of our approach should be taken into account. Most of the data collected is based on self-assessment during an app use in real life. The missing possibility to validate collected data is a well-known problem in the evaluation of digital interventions.<sup>74</sup> The number of app users remained below expectations, resulting in a small sample that did not allow for subgroup analysis. Though the sample size can be regarded as small, it is comparable to other projects.<sup>12</sup>

Voluntary study participation may have resulted in a selection bias, with primarily participation of highly motivated individuals.<sup>75</sup> Of these individuals, only those with programme completion were analysed in the complete case analysis, which entails a potential overestimation of positive effects.<sup>76</sup> Compared with those who did not complete the programme, these individuals used other health apps less frequently and had a lower BMI. Therefore, it is likely, that especially individuals who previously had little app experience completed the programme. Furthermore, a financial incentive was offered for study participation through reimbursement of programme costs, which may also have influenced the sample composition.<sup>70</sup>

Broad inclusion criteria with only limited restrictions caused an inhomogeneous study population, in terms of individual characteristics such as age, BMI and baseline activity. This is matched by the fact that many results show wide IQR and can be considered as inconsistent. Due to its observational design, the absence of a control group and missing randomisation, this study can only provide limited data on how individual app components contributed to the overall effect of the app. This is relevant as the investigated app can be defined as a complex intervention entailing multiple components. In addition, the observational study design did not allow for controlling potential confounders relating to the use of additional apps in parallel to study participation. Thus, the small sample size made it difficult to account for confounding factors during data analysis. Additionally, it was not possible to conclusively clarify which individuals could benefit most from app use.

The app was regularly updated by the responsible company during the period of data collection, without changing any essential content. Nevertheless, small changes of the design, or the app performance could have led to different display of the content.

Additionally, the time of completing questionnaires was based on the programme duration which substantially differed between participants. This is in line with the approach of a pragmatic study but may have introduced a risk of measurement bias affecting internal validity.

## Outlook

While most apps for increasing physical activity focus on documenting activity,<sup>12 77</sup> 'VIDEA bewegt' offers a novel concept in which video-based information, practical

guidance and helpful tips are provided. Such interventions are particularly in demand at times of the COVID-19 pandemic to counteract restricted activity through lockdown policies,<sup>78</sup> minimising the risk of severe COVID-19.<sup>79</sup> The results of the 1-year follow-up are still awaited, which will clarify the important question of the sustainability of observed effects. With special regard to the described limitations of this study, future projects should aim for a larger sample to allow for subgroup analyses. At the same time, the proportion of missing data should be minimised by including a less heterogeneous sample. In addition, a more direct way to contact the participants should be considered. The quality of the results would also benefit from data collection methods not solely based on self-reported values.

## CONCLUSION

Although significant benefits of physical activity were observed following a complete-case-analysis after eight programme weeks, results should be dealt with caution. Using 'VIDEA bewegt' resulted in an increase of physical activity for some participants. As such, significant increases in MET minutes per week and health-related quality of life as well as significant decreases in time spent sitting and BMI were reported by programme completers. Overall, the combination of educative strategies, video-based exercise tutorials and motivational support seemed promising. Future research is warranted to evaluate the effectiveness of the whole programme using rigorously conducted trials while enrolling a larger number of participants.

**Contributors** TF and PS wrote the manuscript, collected the data and performed the data analysis. TF focused on the analysis on physical activity, health-related quality of life and the exploratory analysis, while PS focused on self-efficacy. PEHS advised and provided feedback and reviewed the manuscript. He also is responsible for the overall content of the paper as guarantor. PT regularly provided feedback on the overall study flow and participated in the writing of the manuscript. All authors reviewed and approved the final version of the manuscript before submission.

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**Competing interests** The principal investigator PEHS was involved in the development and implementation of the app 'VIDEA bewegt' as a medical expert. He is responsible for the medical and theoretical background and is shown in the app's videos. He received no payment for his participation in the app.

**Patient and public involvement** Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

**Patient consent for publication** Consent obtained directly from patient(s).

**Ethics approval** This study was approved by Ethics Committee of the Technical University of Dresden (EK 272062019).

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**Data availability statement** Data are available on reasonable request. Individual participant data collected during the trial will be available after deidentification and completion of data collection. Data will be shared with researchers who provide a

methodologically sound proposal. Proposals should be directed to peter.schwarz@uniklinikum-dresden.de. To gain access, data requestors will need to sign a data access agreement.

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